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THE TELEPHONE.

THE recent expiry of the Bell Telephone patent has, we believe, hardly led to the brisk trade in telephonic instruments which many manufacturers anticipated; possibly the lull may be only a temporary one, and it may cease when the second master patent, that of Edison, has lapsed, as it does in the middle of next year. It is not improbable, however, that the National Telephone Company may not consider that their claws have been completely pared down; but that, as owners of comparatively recent patents dealing with important details, they have still plenty of fight left in them. The question as to licenses to be granted by the Postmaster-General for rival telephone exchanges is yet in abeyance, and until something definite is decided, but little can yet be done. There seems to be an impression abroad, however, that were action made free, formidable competitors with existing systems, in the shape of instruments for loud-speaking and long-distance working, would soon spring into existence. Those who imagine this must be profoundly ignorant of the laws which limit the possibilities of telephonic working, and which are as definite as those which limit the possibility of working submarine cables beyond a certain speed. We have more than once alluded to what is known as the "K R" of a telephone line, and it is surprising how very few seem acquainted with, or realise the exact significance of, the law therein expressed. We hear it glibly stated that telephonic communication, say, between London and Glasgow, a distance of over 400 miles, would be quite practicable, it is only a question of getting instruments powerful enough. Undoubtedly it is possible to speak that distance and to speak well, but it is not a question of instruments at all, it is a question of wire; make the latter of copper and sufficiently heavy and the thing is done, but then will it pay? What return on the total cost of a copper double wire, weighing not less than 400 lbs. (and probably 600 lbs.) per mile would be required to be remunerative.

Seeing the wide spread area over which the National Telephone Company have cast their network and the number of their subscribers, it seems difficult to see how the public will be induced to subscribe to a rival exchange, as it will naturally be very annoying for the subscribers to find that the persons with whom they desire to converse are not on their particular system; even the inducements of a good service and a low subscription would hardly compensate for this.

In the matter of instruments it is whispered that the National Company are well aware of the unsatisfactory character of the transmitters used by them, but in view of the fact that the introduction of an improved form to even a few subscribers would lead to a general demand all round for the better instruments, and a consequent heavy outlay, they are unwilling to issue any other type than that in universal use, viz., the Blake pattern. Referring once again to long-distance speaking, it is probable that the commercial value of the new London and Paris line may inaugurate a new era in telephonic enterprise. It is difficult to forecast whether this will be a financial success, but the result of the experiment, commercially, and not scientifically speaking, will be looked forward to with great interest. We say "not scientifically," because the satisfactory working of the line, telephonically, we consider to be, beyond doubt, the margin beyond the practical "K R" limit, being amply sufficient to ensure success. At the same time, many will, no doubt, consider the experiment as an engineering triumph.

TEMPERED COPPER.

THE *Journal of the Franklin Institute* for December contains the report of a sub-committee appointed to decide upon the merits of the products of the Eureka Copper Company. The company claims to produce by

new, unpatented (and therefore undescribed) processes, copper castings free from blow holes, and to harden them without destroying their fibre or impairing their usefulness for electrical or other purposes. Chemical analysis showed that both tempered and untempered samples were commercially pure copper. Physical tests showed that the untempered had 20 per cent. and the tempered 35 per cent. greater tensile strength than the average shown by a U.S. Government report (1878). One hundred letters were sent out to users of the material and 53 answers received, "in which a definite opinion was expressed." Of these, five saw no difference between the tempered copper and other metal and alloys; eight had tried it for unsuitable purposes; six were against, and 34 in favour of, the claims of the makers. Amongst the 34 the use of the material for commutator brushes and segments was particularly prominent.

The committee recommend the award to the inventors of the John Scott Legacy Medal and premium, as they "believe that the claims of the applicants are substantiated by the experience of the majority of the parties using the copper, and also by their own investigations."

The prominence thus given to results of practical use by placing them as of first importance, and their own scientific tests as secondary, is somewhat remarkable. We agree fully with the committee as to the importance of practical use, but as the scientific tests are entirely authenticated, and the reports of the users appear to be irresponsible, we think that in this case the order of importance should be reversed. It is not a majority of users who substantiate the claims, but 34 out of 100, 47 either not replying or being indefinite in the expression of their opinions.

The advantages of such a material being considerable, there is no doubt its capabilities will not lack practical tests.

MANNESMANN TUBES.

THE same journal contains particulars of tubes rolled by the method invented by Reinhard and Max Mannesmann. The method is of special use in making pipes designed to withstand heavy pressures. The process consists in feeding a solid heated bar of ingot metal between rolls which, while their axes are oblique to the axis of revolution, revolve both in the same direction. The metal of the surface of the bar thus acquires an increased motion in a spiral direction, and is drawn over its core, receiving, consequently, the form of a pipe. The pipe moves spirally forward, and the metal becomes still denser as its parts are spirally pushed and pressed. Much importance is attached to the spiral arrangement of the metal, apart from the advantage the tubes possess in presenting no lines of welding. The thickness of the pipe may be varied within wide limits from a bore of $\frac{1}{16}$th inch, and an outside diameter of $1\frac{1}{2}$ inch to a bore 95 per cent. of the outside diameter. Whilst the description mentions only iron pipes as having been made, we presume, from the thin tubes above referred to, that the process is applicable to other metals.

ELECTRICAL MINERS' LAMPS.

THE numbers and varieties of these lamps, which are continually springing up, is becoming legion, and one after another they drop into oblivion through having utterly failed to substantiate the claims that are made for them. One may generally judge of the value of these inventions by noting certain of the claims made for the information of the public, whom it is hoped to deeply interest in the matter to the financial benefit of the promotors. At the *Inventors' Institute* recently, a paper "of much interest" was read by Messrs. Gauzentes and Strong, on "A New Miner's Lamp and Primary Battery," the invention of the former gentleman. The following are some of the claims: "The metal which serves for the anode of energy is refined by a new and simple process, and allows us to obtain the maximum production of current without fear of rapid polarisation, which has up to the present proved the great obstacle to the employment of a direct source of electricity." This is the first time we have heard that polarisation took place at the anode of a battery; we were always under the impression that it took place at the cathode, but we stand corrected. The new fluid "can be manipulated without the slightest danger;" other fluids, of course, have proved highly dangerous, and have caused serious accidents, and no primary battery has in consequence been successful before the marvellous invention of M. Gauzentes was brought out. "Total suppression of all local resistance"—wonderful! The battery is guaranteed to last for five years; we wish the undertakers joy if they imagine that such a thing is possible. Cost of maintenance—5d. per 72 to 80 hours, all charges included; candle-power of lamp = $\frac{3}{4}$; we have heard this sort of thing before. A portable table-lamp is stated to give "the happiest results," both as regards "immunity from fire and cheapness." Who that has seen electric table-lamps has not been struck by the absurd disproportion between the size of the lamp and the candle-power emitted. This has always been the case, and we venture to think is likely to continue to be so for some time to come. We do not mean to say that there are not very good points in the invention of M. Gauzentes. There are no indications as yet one way or the other; we have only assertions; but why bolster up what may be a good thing by absurdities? We fear, however, that M. Gauzentes has not made much advance on his plans of several years ago.

The Chelsea Company again.

THE letter of the Chelsea Electricity Supply Company to the Vestry giving notice of its intention to discontinue the supply of electricity between the hours of midnight and four o'clock in the afternoon, in consequence of the fog, is, we think, a grave error. Although only a temporary measure, it seems to give more than a local colouring to the complaints which have recently been directed against this unfortunate company, and Mr. R. Chamberlain will now have additional arguments to support his contention that it cannot carry out its compact with its customers. To cut off light when it is most wanted seems to be a *reductio ad absurdum* of the most childish nature, and we can only think that the grounds for the complaints of Mr. Chamberlain and others are stronger than we had thought.

ON STANDARD WIRE RESISTANCES.

AT the recent meeting of the American Institute of Electrical Engineers a most interesting report was received from the Standard Wiring Table Committee dealing with its researches into the experiments made to determine the resistance of copper. We give the report as it was received, although it has since been somewhat modified by action of the institute in taking the soft copper standard mentioned instead of the hard copper standard.

Preliminary Report of the Standard Wiring Table Committee in Regard to Matthiessen's Standard of Resistance of Copper.

The council of this institute, at its regular monthly meeting, held December 3rd, 1889, appointed a committee "to formulate and submit for approval a standard wiring table for lighting and power purposes." The committee appointed consists of the following members of the institute: Thomas P. Conant, Dr. Louis Duncan, Prof. Wm. E. Geyer, A. E. Kennelly, George B. Prescott, jun., E. Wilbur Rice, jun., Prof. E. P. Roberts, Prof. Harris, J. Ryan, William Stanley, jun., Dr. Schuyler S. Wheeler, and Francis B. Crocker, chairman. This action was taken by the council with the object of overcoming, or reducing the great confusion which now exists in regard to the standards and constants of electric conductors.

At the first meeting of the committee, held January 10th, 1890, it was decided to confine the work at first to the three subjects of standard of resistance, temperature coefficient, and safe carrying capacity of copper, since these are of fundamental importance.

The subject of Matthiessen's standard alone is so confused and involved, and the discrepancies are so great between the best authorities that the committee has devoted its attention almost entirely to this subject up to the present time. After a very thorough investigation of Matthiessen's work with a view to ascertaining what his standard really was, by a sub-committee, consisting of Prof. Wm. E. Geyer, Mr. George B. Prescott, jun., and the chairman, the conclusion has been reached that Matthiessen's "mile standard" (one statute mile of pure copper wire one-sixteenth inch in diameter has resistance of 13·59 B.A. units at 15·5 degrees C.) is not the true one, although very commonly used. We consider the correct Matthiessen's standard, and the one in which he himself had most confidence, was the "metre-gramme" standard (resistance of pure hard-drawn copper wire, one metre long, weighing one gramme = ·1469 B.A. units at 0 degrees C.). This has the disadvantage that it is expressed in terms of weight instead of diameter. It is, however, very much more difficult to get the exact mean diameter of a wire than to get its exact weight, as Matthiessen himself states. Furthermore, by selecting the most reliable constants given by Matthiessen, and corroborated by investigation and correspondence with the best authorities, we have, by calculation, converted this "metre-gramme" standard into a standard referred to dimensions and independent of weight, which is the form generally used. The various constants selected, the method of calculation, and the values deduced, are given in a table at the end of this report.

As to the fact that wires may be found which test 102 per cent of Matthiessen's standard, or even higher, we are of the opinion that this is no real objection, provided the value of the standard is definite and generally accepted. A standard which is not the highest attainable value may be even considered an advantage, since the average commercial wires will approximate to it more closely.

Although we believe the standard we recommend will answer the purpose temporarily, and probably permanently, nevertheless we think that if a thoroughly correct and complete redetermination of the standard resistance of copper could be accomplished it would be a benefit to electrical science and industry. Favourable offers in this direction have already been received by the committee from the John Hopkins University, Cornell University, and Columbia College, and it is very likely that this redetermination may be undertaken.

This committee purposes next to take up the subject of the safe carrying capacity of wires. Matthiessen's standard recommended by this committee is: A hard-drawn copper wire one metre long, weighing one gramme ("metre-gramme"), having a resistance of ·1469 B.A. units at temperature of 0 degrees C.* From this standard we calculate, by taking the value 8·89 for the specific gravity of copper, that a hard-drawn wire one metre long and one millimetre in diameter ("metre-millimetre") has a resistance of ·02104 B.A. units at 0 degrees C. This value is also given by Matthiessen.† Matthiessen's figures‡ for relative conducting powers are: Silver, 100; hard or unannealed copper, 99·95; soft or annealed copper, 102·21.

From these the resistance of hard copper is found to be 1·0226 times that of soft copper; therefore, the resistance of a soft copper wire one metre long and one millimetre diameter is ·02057 B.A. units at 0 degrees C. From this the resistance of one cubic centimetre of soft copper is found to be ·000001616 B.A. units at 0 degrees C. And the resistance of soft copper wire one foot long and ·001 inch in diameter (mil-foot) is 9,720 B.A. units at 0 degrees C. Taking one B.A. unit as ·9889 legal ohm, any of the above values may be converted into legal ohms. To find the conductivity of copper at temperatures other than 0 degrees C., Matthiessen's formula may be used:—

$$C_t = C_0 (1 - \cdot00387\, t + \cdot000009009\, t^2).$$

Table of Values Based upon Matthiessen's Correct Standard.

	B.A. units. 0° C.	Legal ohms. 0° C.
Matthiessen's standard metre-gramme, hard	·1469	·1453
Metre-gramme, soft	·1436	·1420
Metre-millimetre, hard	·02104	·02080
Metre-millimetre, soft	·02057	·02034
Cubic centimetre, hard	·000001652	·000001634
Cubic centimetre, soft	·0000001616	·000001598
Mil-foot, hard	9·940	9·829
Mil-foot, soft	9·720	9·612

Specific resistance of hard copper (1 cu. cent.) = 1634 (C.G.S. units).
Specific resistance of soft copper (1 cu. cent.) = 1598 (C.G.S. units).
Matthiessen's standard specific gravity of hard copper, 8·89.
Resistance of hard copper is 1·0226 times that of soft copper.
Resistance of soft copper is ·9779 times that of hard copper.
Legal ohm is equal to 1·0112 B.A. units.
B.A. unit is equal to ·9889 legal ohms.

After reading the report, Prof. Crocker, the chairman, added the following very interesting details concerning the practical side of the resistance question, and the information that he had been able to obtain as to the classical experiments on which our present standard is based. Prof. CROCKER said:—

"Of course, the derived values follow as soon as the fundamental standard is decided on, and the question, therefore, is, not what the derivations are, but whether the fundamental standard is correct; in other words, whether Matthiessen's 'mile standard' or Matthiessen's 'metre-gramme' standard is the more reliable. Now, the sub-committee has investigated this particular point with a great deal of care, and arrived at a very definite conclusion—that the metre-gramme standard was unquestionably the more accurate and the more reliable of the two, and that Matthiessen himself so considered it. Fortunately, after having decided this, we received a letter from Mr. Latimer Clark, who is one of the best authorities on this matter, and who was a contemporary of Dr. Matthiessen, in fact, he suggested to Dr. Matthiessen that he should undertake these experiments, so he is

* *Philosophical Magazine*, May, 1865.
† *Philosophical Magazine*, May, 1865.
‡ *Philosophical Transactions*, 1864.

specially competent to express an opinion on this subject, and he agreed with our conclusions in every respect. We had already arrived at these conclusions, so his letter was simply corroborative. Mr. Latimer Clark's letter to the committee covered the subject very thoroughly and clearly, and I wish here to express our thanks to him for his kindness. There is, however, considerable confidence in the mile standard, and I think that it is simply that it has been used, and the fact that a mile and a sixteenth of an inch are more familiar values for the ordinary American and English engineer than a metre and a gramme, but the metre-gramme is just as capable of being transformed into practicable and common units as the mile and sixteenth of an inch. The necessity for deciding on some standard is more urgent than would be ordinarily supposed. This morning, for instance, in my ordinary professional work, I referred to two wiring tables issued by presumably competent persons, and both intended to be correct, and both being such as an engineer would use in his practice. One of these tables gave the resistance of No. 25 B. & S. gauge copper wire as 33·4 ohms per lb. at 75° Fahrenheit. The other gave it as 34·7 ohms per lb. at the same temperature. Now, there is a difference of 1·3 ohms in 33 ohms, which is about 4 per cent. In some cases it does not make very much difference whether it is 4 per cent. one way or the other, but 4 per cent. is a very considerable discrepancy, and in a great many cases it would make a very serious difference. For instance, I was figuring on 16 lbs. of wire, and it made a difference of almost 21 ohms. That is not only measurable, but it is a serious matter in some cases. I think that when two wiring tables that electrical engineers ordinarily use differ by 4 per cent., it is time to do something. I just happened to pick up these tables this morning. I did not do so with reference to this subject. I dare say if I looked for discrepancies I could find much greater ones. The adoption of this standard does not mean that every wire used for commercial purposes shall be 100 per cent. of Matthiessen's standard. There is no reason why an electrical engineer in his specifications should not require 101 per cent. if he considers it necessary, and I can think of cases where it might be necessary. On the other hand, it might be sufficient if the conductivity was 97 or 98 per cent. of the standard. It is simply necessary that we should have some definite value.

"The question whether any standard at all is necessary is a more important one; as it is not absolutely necessary to have a standard. We could simply say that one mil-foot or one cubic centimetre of the copper used for a certain purpose should have such and such resistance—in other words a certain specific resistance. But practical men have become accustomed to using Matthiessen's standard, and they seem to want a standard, and they will use one whether we want them to or not; such being the case I think it better to decide what Matthiessen's standard is. It certainly is commonly used. You see the expression in every book and almost every paper and specification, and as it now has no definite value—even though it is not used in the future, just simply to have it settled once and for all, I think it would be well to settle upon a definite standard. We feel sure that the institute will make no mistake in adopting this as Matthiessen's standard, and unless there is some particular objection to it which has not been brought out by our investigations, we hope the institute will do so."

Mr. Geo. B. Prescott, Jun., then added some further details of the committee's investigations and made the suggestion, which has since been followed, of taking the soft copper standard in preference to the hard. Mr. PRESCOTT said: "In making this report the committee has not thought it necessary to go into detail very much, and it may be interesting to members of the institute to know how this discrepancy in what is called Matthiessen's standard has arisen. In the first place, it is perhaps worth while to inquire why this standard was adopted in preference to any other. The reason was because Dr. Matthiessen made a series of careful experiments to determine the resistance of metals and the variation of their resistance with changes in temperature, which extended over a great number of years and formed the basis of the work of the British Association, which decided on the practical standards. It seems that years before this British Association Committee undertook this labour various standards of resistance had been proposed by German, French and English electricians, and they were of all kinds, and among them was one proposed by Dr. Matthiessen, which was this 'standard mile.' There were no ohms in those days, and he made up a standard mile of this copper, and that was used as a unit in England for a long time. Later on, when the committee of the British Association had determined the value of the ohm in absolute units and had prepared practical standards, part of this committee tested the different standards that had been made in different parts of the world, including this standard of Matthiessen, and when they measured it they found that it was equal to 13·59 British Association ohms. Matthiessen never gave it that value; it was simply an arbitrary standard that he selected, because it was a convenient unit. Probably it was the size of wire commonly used in those days, so that really it never was a standard except in that sense. After Matthiessen's work was completed and published, Dr. Fleeming Jenkin, who was the secretary of the association, tabulated the results. Matthiessen's measurements were made with respect to weight and length, and also diameter and length. But his measurements of diameter were always very unsatisfactory, and finally the only measurements that he really relied on were those of length and weight. But he made a very great mistake, which he himself acknowledges in his reports, which was that he neglected to take the specific gravity of the actual samples that he experimented on, and the result, of course, is easily understood. Every sample of copper varies somewhat in its physical properties, and if you were to take one hundred samples of wire, and measure their resistances at a given weight and length, and then attempt to calculate the resistance from the cubical dimensions, you would find a difference, simply because there is a difference in the drawing of wires which changes their molecular constitution. Dr. Matthiessen neglected to take the specific gravity of any sample of wire that he tested, and the result is that we do not know to-day what Matthiessen's standard is, except in terms of weight and length.

"A further complication arose in this way, that Dr. Fleeming Jenkin, who, as I say, tabulated the results which Dr. Matthiessen obtained, made all sorts of derivations, giving the resistances in foot-grains and foot-mils, and metre-grammes and metre-millimetres—all by calculation. Of course, in converting from length and weight into length and diameter, he had to use specific gravity. He selected certain specific gravities. In his original table there are errors. Those errors have been copied. Other people have calculated tables from the standard mil unit, and, of course, they give different results, so when Matthiessen's standard is referred to to-day, there is a great deal of uncertainty as to which standard is meant. As a matter of fact, the statute mile standard is probably nearer the true resistance than the metre-gramme, for the reason that it gives a higher conductivity, and there have been any number of cases of wire being tested that had greater than 100 per cent. conductivity, and it was for this reason that seven or eight years ago I calculated a wire table, and selected this unit of Matthiessen's simply because it was the lowest, and agreed with some results that I had actually obtained."

Mr. GEORGE C. GROWER said: "I think there is a mistake made when hard copper wire is assumed as the standard and the resistance of soft copper reckoned from it. This takes for granted that there is a fixed ratio in resistance between hard and soft copper. But this ratio depends entirely upon the hardness of the hard copper compared with the soft. For instance, if you take large copper wire and have it as hard as you can get it, the conductivity would be almost as good as

soft copper, while in a small wire it would not be nearly so good. I have had as much as 8 per cent. difference between hard and soft copper made out of exactly the same stock on small wires. If we should make the wire very small, I dare say it would make still more difference.

"I agree with the committee that the metre-gramme standard is the more reliable, because whenever I have tried to make tests with diameter I could not get any sort of agreement among them; but where I take soft copper standard, no matter what the size of the copper is or anything else, so long as it is soft copper and from the same stock, I get almost the same result. But if you take hard copper for the tests, the tests will differ several per cent., according to the size of the copper. I think, for that reason, the standard should be of soft copper of a given length and weight."

Mr. CROCKER said: "It is perfectly correct as an abstract statement that soft copper is more constant in its resistance than hard copper. Hard copper can be made of almost any resistance up to several per cent. above soft copper. But soft copper is not Matthiessen's standard; it is precisely like the case of the foot. The English foot originally, I have heard, was the length of the King's foot. Well, now, at the present day, I think it is a little in excess of the average length of the human foot. But it does not make a particle of difference, providing it has a definite value, as it has, and providing a correct copy of the standard is kept in a safe place—it does not make any difference whether it is an inch longer or an inch shorter than the human foot. It has a definite value, and no one, I think, at the present time, would recommend changing the English foot, as a unit of measurement, to agree more closely with the length of the anatomical English foot. It is precisely the same with Matthiessen's standard. Unfortunately or fortunately, as you may look upon it, Matthiessen has promulgated a standard, and it has been largely, in fact almost universally accepted. Now all that is necessary is to adopt a definite value for this standard. It does not make much difference what it is, provided it is definite and generally accepted. Of course, in selecting a definite value, we want to select the best one, the most reliable one, the one that he himself considered most reliable, and the one that other authorities deem the best. So it seems to me that the mere fact that one standard or another approximates more closely to what the highest possible value is, or the fact that one or the other happens to be easier to determine in practice, makes no great difference, provided we get a certain definite standard or resistance for various lengths, weights, diameters, and kinds of copper. I think that all that is necessary is to free this subject from its great confusion by simply adopting a definite standard, and if that standard happens to be more correct than some other, so much the better; but even if it is not, it is very much better than confusion."

It is to be hoped that this report of the Standard Wiring Table Committee will receive the attention it deserves, as it certainly has gone far to straighten out the complex tangle into which some careless copying of constants has led. The report is both a judicious one and worthy of receiving general adoption.

RESEARCHES IN THERMO-ELECTRICITY.*

By Messrs. CHASSAGNY and H. ABRAHAM.

WE have already shown † that the electromotive forces of thermo-electric couples, the junctions of which are kept at 0° and 100°, may be determined within $\frac{1}{10000}$th of their value.

We must observe that when, as in our experiments, the equilibrium of electromotive forces is shown by a galvanometer of low resistance, this degree of accuracy is retained for the lesser electromotive forces given by these couples at the intermediate temperatures; the resistance introduced into the circuit of the galvanometer diminishing with the electromotive force to be measured, the absolute sensibility of the instrument increases, and the relative accuracy of the measurements thus remains almost constant.

We see, then, that thermo-electric couples employed as thermometers for registering very minute variations of temperature show the hundredth part of a degree between 0° and 100°, and they have this advantage over the ordinary thermometers that the smaller the variation of temperature is, the more accurately is it indicated.

In order to find the relation between the electromotive forces of the iron-copper couple and the scale of temperatures of the hydrogen thermometer, we measured these electromotive forces at different temperatures between 0° and 100°, one of the junctions being in ice, and the other in a bath of water stirred continually and placed in a regulating stove.

A thermometer placed beside the joint shows at each moment the temperature of the bath. The thermometer is of toughened glass, and was supplied by M. Tounelot, and the readings taken on this instrument were corrected and reduced to the scale of the hydrogen thermometer by means of the tables published by the International Bureau of Weights and Measures, where this subject has been studied.

We found, moreover, that the indications of this thermometer and those of a second thermometer of the same type, placed in the same bath, in no instance differed from one another to the extent of $\frac{1}{100}$th of a degree. The temperature of the baths varied very slowly, and these slight variations were indicated almost simultaneously by the thermometer and by the thermo-electric couple, the latter, however, always acting first.

A parabolic formula of two terms is quite incapable of showing the relation between the electromotive forces and the corresponding temperatures of the hydrogen thermometer, the discrepancies between the temperatures calculated by means of such a formula for 50° and 100° and the temperatures actually observed, amounting to + ·12 of a degree at 25° and − ·13 of a degree at about 75°. The following empirical formula, although still not representing the measurements with absolute accuracy, will give their values within $\frac{1}{200}$th of a degree, between 0° and 100°.

$$E_0^t = \frac{at + bt^2 + ct^3}{t + 273},$$

$$a = 10^{-3} . \ 3{\cdot}56604$$
$$b = 10^{-6} . \ 8{\cdot}3827$$
$$c = 10^{-9} . \ 3{\cdot}265$$

as shown by the following figures, taken from the same experiments:—

Value of E_0^{100} = ·0010932 of a volt.

Temperatures.	Electromotive forces.	
	Observed volts.	Calculated volts.
65·13°	·0007656	·0007654
32·49°	·0004043	·0004045
15·48°	·0001981	·0001980*

* Experiments performed at the higher *Ecole Normale*.

Dangers of Electric Wires.—Last Thursday while six horses were drawing a snow-plough along the streets of Portland, Maine, they came into contact with a broken electric wire and three were killed instantaneously.

* *Comptes Rendus*, November 17th, 1890.
† *Comptes Rendus*, vol. cxi., pp. 477 and 602; 1890.

THE OHIO STATE TRAMWAY ASSOCIATION.

THE opportunities for American electrical engineers to ventilate their ideas are quite in keeping with the general progress of the science. Not only do our American friends institute a number of "Conventions," purely electrical in their aims, besides attending the usual and frequent meetings of electrical societies and clubs, but they are now thoroughly invading the conclaves of tramway men, who, by force of circumstances, are all becoming amateur electricians and staunch supporters of the new motor. The Ohio State Tramway Association held its ninth annual meeting at Columbus, O., November 19th, when the President invited representatives of several electrical firms to describe to members the special features and advantages of each system. No papers were offered or read, but Mr. C. K. Harding, of the Harding Electric Railway Company, Atlantic, Iowa, opened the discussion by making reference to underground systems of distribution, in which, he regretted, the foreigner had taken the lead up to the present. The speaker passed on to a criticism upon overhead conductors, objecting to the unsightliness of wires and poles, the danger to other wires, interference with telephones, liability to damage from lightning, and the comparatively low voltage adopted, which is necessary for the safety of animate beings, but which does not offer the greatest economy and efficiency for distribution over large areas. In order to avoid these difficulties, Mr. Harding devised a closed conduit system which savours very much of inventions brought out in England at various periods. The following is the speaker's own description:—It should be understood that to preserve insulation you must exclude water, and to do that the conduit must be entirely closed, without slot or other opening through which the current is taken. In order to accomplish this result, I employ a tubular iron casing, in the top of which is a channel or flanged portion in which are insulated and supported the sections of the working conductor. These sections may be from 4 to 6 feet long, and extend an eighth of an inch above the surface, and are normally insulated from each other, the casing and the main conductor, which extends through the lower tubular part, and is entirely surrounded and embedded in the insulating material. In the end of each section of the casing or conduit there is an enlargement of the lower tube, which forms a junction box in which is located a small electro-magnetic contact, making a device which, when operated, connects its conductor section with the main or supply conductor. One end of the winding on the magnets of these contact devices is connected through a simple switch to the adjacent working conductor section, and the other end directly to the conductor section on the other side by means of this arrangement, and a second brush on the car. I employ a very small portion of the current to operate automatically the contact device, and bring the exposed sections of working conductor separately and successively into connection with the main insulated supply conductor when these sections are immediately under the car and protected by it. In other words, I get the current to the car through the series of insulated exposed sections which are fed from the main conductor as the car passes along, and are at all other times completely insulated from the wire carrying the current. By employing a derived circuit in multiple arc with the motor circuit, I am enabled to use a very small portion of the main current for the operation on the contact devices, and to make the magnets of small size and wind them with iron wire, thus making the construction of the contact-making devices a comparatively simple matter, and permitting them to be placed in a small closed cavity in the ends of the sections, where they will be readily accessible and interchangeable."

Mr. Curtiss, of the Short Electric Railway Company, stated that the greatest objection to electric railroading in its practical operation has been the one item of repairs. In one town, he was told by a gentleman connected with the road, that the repairs last year amounted to $1,100 per car. The Muskegon (Mich.) road, constructed by the Short Company, had been running for six months, commencing with five cars, and increasing to nine, but the repairs had not exceeded $100 on all the electrical equipment.

Mr. C. A. Benton, of the Detroit Electrical Works, assured the audience that his firm had 21 cars running at Saginaw (Mich.), which have been in operation for 11 months, and the cost of repairs had not reached the sum of $50.

Mr. W. J. Cooke, of the McGuire Manufacturing Company, advocated heavy trucks carrying electric motors, and he maintains that most of the trucks built at the present day were far too light, therefore not sufficiently strong. He did not mind carrying 1,500 lbs. in addition to what is the usual practice. Mr. Cooke also spoke of an electric heater, consisting of a ribbon running along the edge of the seat. The temperature can be varied to any degree by the driver who commands the switch which conveys the current from the trolley wire to the heater.

Mr. Bronnell, of the Bronnell Car Company, also dwelt upon constructive details of the cars. In most of the electric trucks the motors are located very close to the ground, underneath the car, which makes repairs very difficult, and involves laying up the vehicle during repairs to motors. It would seem that the better mode would be the use of a separate motor car of simple construction propelling the passenger car—in other words, he is in favour of electric locomotives.

BRANLY'S EXPERIMENTS ON THE VARIATION OF CONDUCTIVITY UNDER DIFFERENT ELECTRICAL INFLUENCES.

AT a meeting of the Paris Academy of Science, held on November 24th, Monsieur Edouard Branly read a paper, in which he described some experiments upon the variations of conductivity observed in their metallic layers when subjected to electrical influences.

The layers of metal were prepared by spreading metallic dust upon a plate of ground glass or ebonite of dimensions 7 cm. × 2 cm., and then polishing with a burnisher. In the case of copper, a little tin was added to facilitate adherence. Such a layer is capable of a resistance which may vary from several ohms to several millions for the same weight of metal.

If a circuit be formed containing one of these prepared layers, a high resistance galvanometer, and a Daniell cell, only a very insignificant current is able to pass. An abrupt diminution of resistance, accompanied by a marked deviation on the galvanometer, is exhibited when electric discharges are produced in the neighbourhood of the circuit by the action of a small Wimshurst machine or a Ruhmkorff coil. This effect diminishes when the distance of the losses of discharge is increased; but it is easily observed, without special precautions when the distance is increased to several metres. By making use of a Wheatstone's bridge, it has been observed when the distance has been 20 metres.

Besides the behaviour of a thin layer of copper, that of similar layers of iron, aluminium, antimony, cadmium, zinc, bismuth, and several other metals were examined.

Check experiments were devised by Branly, and carried out, in which a capillary electrometer played an important part; but the results were in every respect confirmed.

Branly has examined the condition necessary to produce the observed phenomena, and with the following results:

It is not necessary that the circuit be closed, but the diminution of resistance is best produced if the metallic layer is bound by its extremities to the conducting wires.

The passage of an induced current through the layer

produces the same effect as that of a discharge in its neighbourhood.

When working with continuous currents, the passage of a strong current renders the metallic layer better able to transmit a full current.

The best results were obtained when, in these experiments, were substituted for the plate of glass and ebonite covered with metallic layers; what M. Branly calls "tubes à limailles," that is, tubes of glass or ebonite which have been treated with fine metallic filings mixed with some non-conducting liquid.

THE ELECTRIC LIGHT IN AGRICULTURE.

[FROM A CORRESPONDENT.]

IN Hungary, where, until very lately, agriculture was almost the exclusive employment of the majority of the population, the electric light met with its earliest application in agriculture. It was used to thresh out the grain by night by means of movable light apparatus, driven by the locomotive of the steam threshing machine, in order to complete the threshing more quickly on large farms. Strangely enough, however, this arrangement, in spite of its great convenience, has still met with only a relatively small application. Baron von Steiger Münsingen has therefore taken the trouble to explain the advantages of threshing by the electric light on the basis of actual figures as obtained from his own practical experience. I think that I shall do many of your readers a service if I give the facts a wider circulation through the medium of your valued paper.

Where the farmer is limited to a certain number of labourers, and cannot procure more, it is no small convenience if they can be rendered available for other duties by a more rapid completion of the threshing. The economy of fuel is not to be despised, as the consumption is considerably less if the boiler is kept constantly hot than if it is let cool down, and steam has to be got up afresh every morning.

Night work is particularly advantageous for the possessor of threshing machinery, which can be hired out, as the machine can thus, in a single season, earn half as much more hire.

Much of this advantage can indeed be also secured by using more powerful machinery. But we must not forget, *e.g.*, an eight horse-power machine costs more than ten times as much as a lighting installation such as is needed for threshing.

In the work this season there was used an 8 H.P. threshing machine by Clayton and Shuttleworth, which had already served for eight seasons. The illuminating installation consisted of a dynamo, an arc light (in a bye-circuit) of 800 normal candles and their accompanying fittings. The cost of the entire installation, including the cart built at home, was 500 florins.

The first question was whether the engine, whilst working the threshing machine at full power, could supply at the same time the necessary power for the dynamo. My anxiety proved quite needless, as the requisite 1,400 rotations of the dynamo were obtained with the utmost ease without any higher pressure of steam. The engine, therefore, whilst working the threshing machine, had still a larger excess of power than was needed for the production of light.

The electric light installation connected with the threshing engine has been in action on my estate for 206 hours in 32 nights, or an average of 6·43 hours per night. The whole work effected this season in 922 hours was 751,900 kilos., or an hourly average of 815 kilos. Of this total there were obtained in 716 hours of daylight 589,000 kilos. or 822 kilos. hourly, and in 206 hours in the night by the electric light 162,900 kilos., or 790 kilos. hourly.

The ordinary hours of work in threshing begin at 5 a.m. and last, with half an hour off for breakfast, an hour at noon, and half an hour (time not stated), till 8 p.m., or 13 hours, which I may call a normal threshing day. If calculated into such days, the performance of the above-named plant would be 55·07 normal days by daylight, and 15·85 normal days by electric light, with an average result of 10·602 kilos. per normal day. Including Sundays and holidays, time lost by bad weather, removing the machinery, &c., there was a clear saving of three weeks effected by the use of the electric light.

If we suppose a constant light installation, working without disturbance, which is quite practicable, the proportion of the night work to the day work comes out more favourable. We have taken the normal day at 13 hours (from 5 a.m. to 8 p.m.). The night work from 8 p.m. to 5 a.m., is 9 hours, from which 1½ hour has to be deducted for lubrication and other stoppages, so that there remain 7½ hours of night work.

On using the night for threshing, changing the workmen of course at noon and midnight, the effective time for work would come to 20½ hours per calendar day of 24 hours. Of these, on account of the short summer nights, 6 hours would be by electric light and 14½ hours by daylight. The resulting gain of 1½ hour of daylight work results from the relay of workmen. We know that the average yield of an hour by night is 790 kilos., and that of an hour by day 822 kilos., so that the total yield of an 8-H.P. installation will be 16,659 kilos. per calendar day, as against 10,602 by daylight only.

Taking the present total yield of 751,900 kilos. of the above described installation as a datum, it appears that a threshing season of 45 calender days, with the aid of the electric light, is equal to 71 calender days with daylight alone. Hence, in the present case, there is the important economy of 26 days, or, in round numbers, a month.

As regards the remunerating character of the process, the author does not indulge in hypotheses of a threshing season without drawbacks, but takes the figures as resulting from this season's work, though it took place under unfavourable circumstances.

On the whole, 162,000 kilos. were actually threshed out by the electric light. If, in order to effect the work in the same time, this quantity had been threshed with a hired plant, it would have cost, on the usual hire of 4 per cent. in kind of the threshed grain, 6,516 kilos., or at the average price of 7 florins per metric cwt. on all the grain, 456·12 florins. Fuel and lubricants are not taken into account, as they remain substantially the same, whether the plant works without intermission, or if two work simultaneously. The lubrication for the dynamo has to be taken into account, as also the carbon rods, and the sinking fund for the lighting plant.

The consumption of lubricants for the dynamo for the entire 206 hours was 1½ kilo. of oil, of the value of 63 kreuzer. A pair of carbon rods, lasting 10 hours, cost 22 kreuzer, or per hour 2·2 kreuzer, or per metric cwt. 0·27 kreuzer, or for the entire season 4·53 florins.

As for the sinking fund, it may be reckoned in two manners. We may place the cost price of the installation of 500 florins opposite to the 450 florins earned by a hired installation. Next year, therefore, the plant would only have to earn 50 florins, and it would then work gratuitously, with the exception of the trifling cost for carbons and oil.

Or we may deduct from the cost price 20 per cent. sinking fund, and 5 per cent. interest, or, together, 125 florins.

Breakdown of Telegraphic Arrangements.—Lord Salisbury was the victim of a breakdown in the telegraphic arrangements while delivering his speech at Waterfoot some days ago. The room in which the telegraphic apparatus was situated appeared suitable at first, but after the gas and stoves had been lighted it became so damp that the perforated paper ribbon used to work the Wheatstone automatic apparatus was rendered useless. So soon, however, as it became evident that the apparatus was unworkable arrangements were made for the report to be transmitted partly by hand signalling and partly by train to Manchester.

A SYNTHETIC STUDY OF DYNAMO MACHINES.

(*Concluded from page* 546.)

X.—WORKING INDUCTION.

THE curve, A, B, in fig. 150, shows the work expended in carrying each cubic centimetre of the armature iron through a complete magnetic cycle at different degrees of induction, as explained in a previous article (p. 356). At first sight it might be imagined that a considerable benefit is to be derived from having a low working induction, but it must not be forgotten that for a machine of specified output, a low induction means a nearly proportional increase in the mass of iron in the armature. Taking a Gramme machine with the armature core pressed up to the usual induction of 17,000 C.G.S. per square centimetre, the ordinate to the curve, A, B, at the point represented by 17,000 on the line of

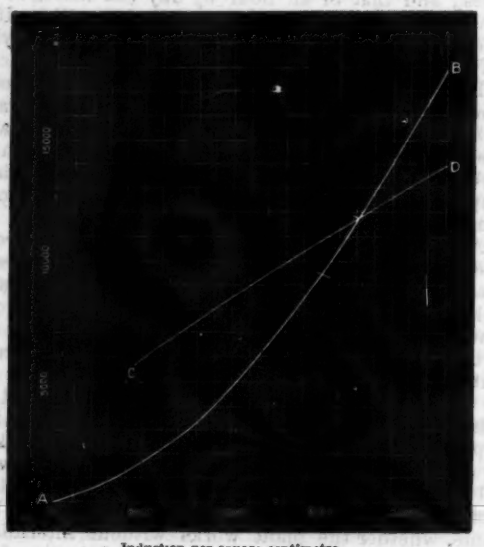


FIG. 150.

abscissæ may be taken as representing the work done in magnetising and demagnetising the armature. If the radial depth of the armature core were doubled, the induction would be only 8,500, and the weight of iron would be nearly doubled, the exact increase of the latter depending, of course, on the relation of the radial depth to the diameter. However, assume it doubled for the sake of argument, and the curve, C, D, shows the energy expended for different degrees of induction. The lines cross at 17,000, as this is the normal induction for Gramme machines, C, D being drawn with the object of comparing the expenditure of energy for higher and lower working inductions with that at the normal. To draw this curve, all the ordinates of A, B are multiplied by the ratio of 17,000 to the induction for which they represent the energy expended, the assumption being made, as above stated, that the mass of iron is inversely as the induction. It will be observed that though the work expended per cubic centimetre for an induction of 8,500 C.G.S. is only 3,700 ergs as against 11,800 ergs for an induction of 17,000, the amounts of work expended for 8,500 and 17,000 respectively in armatures for similar outputs stand in the ratio of 7,500 to 11,800. It will also be noticed that for any given output there is only about 8 per cent. more power wasted in hysteresis at an induction of 17,000 than at 15,000.

This last statement shows that, for cylinder armatures not much is to be gained by reducing the induction from the first to the second figure, while there is certainly something to be lost. If the radial depth of an armature is increased, it requires more wire to go round the core, which, consequently, has a higher resistance, while for series arc lighting, for which this class of machine is eminently suited, the armature becomes, by reason of the low induction, useless. For arc-lighting the armature should have an induction higher, if possible, than 17,000—in fact, the higher the better, since one of the essentials for good working is that the characteristic shall drop considerably in the vicinity of the working current, and that a relation shall be established between current and difference of potentials such that as the former increases the latter diminishes, and *vice versa*. In four-pole Gramme machines it is usual to employ a working induction of about 14,000 C.G.S. per square centimetre.

In armatures wound on the drum or Siemens principle, it is usual to work at an induction of from 13,000 to 14,000 C.G.S. if ample means of ventilation are provided. Where no means of ventilation exist, and the whole of the heat has to be got rid of by radiation from the external surface, the working induction is generally from 10,000 to 12,000. Here, for a machine of given output, it is obviously of no advantage to increase the induction, while something is gained by keeping it low. The diameter of the armature being settled with reference to the number and size of conductors, there is nothing, save as regards weight, to be gained by cutting away the interior of the plates. On the contrary, by making the central opening as small as possible, there is a reduction in the loss due to hysteresis, the magnetising force required for the armature is smaller, and these advantages are not counterbalanced, as in the case of cylinder armatures, by any increase in the resistance of the conductors. In machines of the drum type, having more than two poles, the interior opening in the armature core allows of good ventilation, and accordingly the working induction is generally between 13,000 and 14,000—very often the latter.

As regards the induction in the air gap, generally it will be found that this is very similar for both cylinder and drum machines averaging from 5,000 to 6,000 C.G.S. per square centimetre, though occasionally rising in the drum type of machine to 7,000. The number of ampère-turns which can be carried by the armature consistent with freedom from sparking, as influenced by the induction in the air gap and its dimensions, has been already discussed.

The induction in the magnets varies considerably in different types of machine. For annealed wrought iron forged bars 15,000 is usual, while in cast iron the induction is very much less, being generally from 7,500 to 8,000. Of the total lines of force which pass through the cross section of the magnets where the flux is greatest, only from 70 to 80 per cent. are utilised, the remainder choosing a path of their own outside the armature, and constituting a waste field. The magnitude of this field depends on the design of the machine, and the circumstances influencing it have been already discussed.

In penning these articles, an attempt has been made to place before our readers the latest considerations respecting dynamo designing. While we have been publishing them many important papers on dynamo construction have appeared, while several new designs of machines have been described and illustrated in our columns. Necessarily the simultaneous publication of these has narrowed to some extent the scope originally proposed for these articles, but that a large amount of ground has been gone over will be readily admitted by those of our readers who have followed the papers from the beginning. The one section which has not received attention in the present series, namely the regulation of machines, we find it advisable to postpone for the present, partially influenced by the above reason. But we trust that so far as we have gone our efforts have not been without benefit to our readers.

AN ELECTRICAL LOAD EQUALISER.*

By C. O. MAILLOUX.

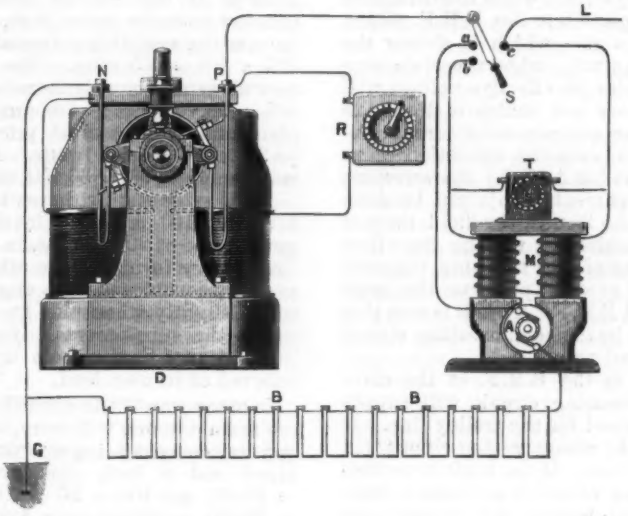
THE task allotted to the steam engine in electric railway work is not an easy one. It would indeed be difficult to contrive a more crucial test than such work affords of the regulating qualities and mechanical endurance of an engine. The load is incessantly undergoing fluctuations which are not only sudden, but extremely severe. An interval of a few seconds often marks the jump from light load to the maximum capacity of the engine, or else a sudden release from full load to no load. Yet, under these trying conditions, the engine is required by the electrical engineer to satisfy in turn and collectively the three important requirements of close regulation, great mechanical endurance and high economy. It is almost needless to say that these three qualities have not yet been reconciled under such conditions. In electric railway practice, it is not uncommon to find a 100 H.P. engine carrying an average load of from 40 to 60 H.P. The fact that the load is likely to jump up now and then to 100 or 120 H.P. makes this margin necessary, for without it, the first two qualities, regulation and endurance, could not be secured. As for the third quality, it is of necessity sacrificed. Even under this compromise the durability, as experience shows, is not by any means an assured quality. Practice is indeed drifting to the conclusion that a further compromise must be made to favour still more the second at the expense of the first quality, and engines of slow-speed types are coming into use. This change also favours the third quality incidentally, but only to a remote degree.

The question of economy in electric railway working is not altogether one of engine type or capacity for the particular case. The efficiency of an engine running light is zero; that of an engine overloaded and taking steam during the entire stroke is also very low. Between these two extremes there is a point of maximum efficiency, corresponding usually to the nominal rated capacity of the engine. If the engine can be worked at this capacity, and if fluctuations much above or below this load can be avoided, the conditions will no longer be incompatible with, but will become favourable to, efficiency. With a steadier, more uniform load, the problem of speed regulation of course vanishes, while that of durability becomes greatly simplified.

It was this reasoning which led the writer, some time ago, to devise a method of equalising the engine-load by electrical means, and of rendering the engine independent, to a great extent, of the fluctuations in power consumption on the trolley lines. The method aims to accomplish electrically for the dynamo what the fly-wheel does in a mechanical way for the engine. It provides the circuit with a kind of reserve fund of energy that is ready to instantly appropriate any surplus of electric power when the load is light, or make up the deficit when it is heavy.

The method consists in connecting to the terminals of, and in parallel with, the ordinary generating dynamo, D, supplying feeder circuit or trolley line, L, a compensating circuit, including a series of storage battery cells, B, B, and the armature, A, of a small supplemental generator. The field magnet coil, M, of this small generator consists of a few turns of large wire similar to the series coil of a compound wound machine. This coil is not included with the armature in the compensating or branch circuit, but is placed in the circuit leading to the trolley line. Consequently, when the circuit switch, S, is thrown to the left, thereby connecting the dynamo to both points, *a* and *b*, and closing both the main and branch circuits, the current sent out to the trolley line, L, will pass through the coils, M, suitable means, such as a shunting rheostat, T, being provided, whereby the effectual ampère turns due to a given current may be adjusted.

The armature, A, of the small machine is driven at constant speed by power obtained from any convenient source, as, for instance, the same engine that drives the main dynamo, D. It might be driven by a separate engine, or by an electric motor supplied from the trolley circuit. This armature is made of low resistance, and capable of carrying a large current.



The cells, B, B, may be of any form, although the Planté type is preferable on account of its simplicity and its ability to withstand severe rates of charge and discharge without injury. These cells need be but of small capacity or only partially formed, since the storing capacity required of them is very small, as will be seen. The number of cells required will depend on the voltage of the circuit. For a 500-volt circuit, which is the usual standard in electric railway practice, a series of about 225 cells would be required. The facilities for adjustment are such, however, that the number of cells may be varied considerably without detriment. It will be seen from the connections that so long as no current is consumed on the line the armature, A, will have its field demagnetised. It therefore generates practically no E.M.F., and constitutes merely a dead resistance.

By the passage of current to the trolley line the field magnet coil, M, is excited and made to produce a definite amount of field magnetism. It is evident, therefore, that the E.M.F. of the armature, A, will depend altogether on, and will rise or fall directly with, the current consumed on the trolley lines. This E.M.F. is so "poled" as to add itself to that of the cells, B, B. It results that when there is no power consumed on the

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trolley line the voltage of the cells, B, B, will be so much lower than that of the dynamo, D, that there will be a large "overflow" of charging current into them. As the power consumed on the line, L, is increased, the armature, A, will begin to generate an E.M.F. that will raise the effective voltage of the battery and consequently reduce the charging current, until finally at a certain point it will stop altogether. If the current now rises above this limit, it will raise the effective voltage of the compensating circuit above that of the dynamo. Consequently the battery will now begin to discharge current into the circuit just as if it were another dynamo coupled in parallel with the main dynamo, D. When this point is reached, if the field magnet of the small machine is still much below saturation, the further increase of the current may raise the effective E.M.F. of the compensating circuit considerably higher than that of the dynamo. It might seem, therefore, that the dynamo, D, is likely to be overbalanced and converted into a motor.

There is another important factor that intervenes here, however, viz., the polarisation of the battery. It is well known, as one of the disadvantages of storage batteries, that their potential difference is diminished as the discharge current is increased, partly owing to their internal resistance and partly to the effect of polarisation, the latter being especially marked with heavy discharges. It follows from this that the effectual voltage of the compensating circuit when the discharge begins, will not rise in proportion to the E.M.F. added by the armature, A, but at a rate which is slower the greater the current; consequently, when a certain current value is reached the rise in effective voltage will be much slower. If this does not suffice to limit the rise of E.M.F. made in the compensating circuit, the adjustments can be made to lower the saturation point of the field cores, so that the bend of the characteristic may correspond to a lower current. This can be done by suitably proportioning the iron in the field magnet cores; or, with a given machine, by varying the effectual ampère-turns, by means of the shunting rheostat, T, the speed being changed so as to preserve the same total range of supplemental E.M.F. Thus it is seen that the rise of effective E.M.F. in the compensating circuit can be limited at any desired point.

If the limit is the same as the E.M.F. of the main dynamo, then the compensating circuit will supply about half the current required for the trolley line. If the limit is a trifle higher the compensating circuit will supply slightly more than half. If the limit be sufficiently high the compensating circuit will assume practically the whole load, and relieve the dynamo and engine.

It is not necessary, as might appear at first, that the field cores of the supplemental generator should be laminated, to make the apparatus sensitive and responsive to sudden fluctuations. Advantage, again, is taken here of the polarisation of the batteries. It requires a minute interval of time for a storage battery to polarise or depolarise. This interval will practically balance the time required for the rise or fall of magnetisation,

As a case illustrating the operation of the above method, let us take a dynamo of, say, 50,000 watts capacity, supplying a railway circuit at 500 volts pressure. Under present practice the average load put on such a machine would scarcely exceed 60 ampères, and the engine would be of about 100 H.P. capacity, if not more. Instead of this, an engine of about 80 H.P. would be used, and the average load would be made at least 90 ampères. The compensating circuit would then be so adjusted that whenever the current consumed on the trolley line would fall much below 90 ampères the main dynamo would overflow into the battery. If the consumption ceased altogether, for a brief instant, as so often occurs, the dynamo and engine, instead of running empty, would run at nearly the same output, the whole current being sent into the batteries.

As the current increased on the trolley line the overflow would diminish, and, at a little below 90 ampères, it would cease. Any increase above 90 ampères would cause the battery to discharge and help the dynamo. The greater and the more urgent the demand for assistance the more promptly and liberally will the supply be given. Not only will the supply provide for the excess of current required above the 90 ampères furnished by the dynamo, but, as shown above, it may be made to relieve the dynamo itself either partly or wholly.

Let us now analyse the action of the compensating circuit. When there is no current on the trolley circuit the current sent into the batteries will pass through the armature, A, as if it were a dead resistance. When current is consumed on the line, however, the magnetic field becomes excited, and the charging current now operates the armature, A, as a motor. The amount of energy thus re-converted is not large, however, since the charging current is large only when the counter E.M.F., generated by armature A, is small, and *vice versa*. When the working current rises above the adjusted limit of 90 amperes the batteries begin to discharge, and the armature, A, then becomes a dynamo.

Let us assume that the load jumps up suddenly to double its average value, or 180 ampères, and remains so for five minutes. Such severe fluctuations are not infrequent, although they scarcely persist, as a rule, longer than from a few seconds to a minute. Let us assume that the compensating circuit will carry the excess of 90 amperes, making, at, say, 501 volts, an output of 45,090 watts. If we assume that the battery will so polarise at this rate of discharge that it cannot be counted upon for more than, say, 1·8 volts per cell, we have, as the available potential difference of the battery, $225 \times 1{\cdot}8 = 405$ volts. The armature of the supplemental generator will therefore need to supply $501 - 405 = 96$ volts. The amount of energy which the supplemental dynamo must provide will consequently be be $96 \times 90 = 8{,}640$ watts. The battery supplies the rest, or $405 \times 90 = 36{,}450$ watts.

If the same engine drives both dynamos, we see that a rise of 100 per cent. in the current load will only cause a rise of 20 per cent. in the output of the engine. The battery furnishes the other 80 per cent. If, however, we consider that the engine is likely to slacken its speed slightly when the fluctuation occurs, or if we adjust the supplemental dynamo to a slightly higher limit of E.M.F. the main dynamo, D, will be partly relieved of its own load.

In other words, the conditions can be made such that the main dynamo will carry, let us say, only 80 amèpres, and the compensating circuit 100 ampères. The combined load of both dynamos will now be $80 \times 500 = 40{,}000$, and $100 \times 96 = 9{,}600$; total, $40{,}000 + 9{,}600 = 49{,}600$ watts, or only 4,600 watts, or 10 per cent. more than the average working rate of the main dynamo. The battery will supply $100 \times 405 = 40{,}500$ watts or 90 per cent. of the energy required in excess of the average load.

The storage capacity required to compass such a severe and prolonged fluctuation is naturally a question of importance. A current of 100 ampères for five minutes represents a total of 500 ampère minutes, or $\frac{500}{60} = 8{\cdot}33$ ampère hours. Hence, if each cell has a storing capacity of only 10 ampère hours, it will have margin sufficient for all contingencies. Even if doubled, the capacity per cell would still be only about one-eighth to one-tenth of the capacity of the cells used in storage battery traction. For a 50,000 watt dynamo the series of cells required would be equivalent in storage capacity to about one-fourth of the battery usually put into each storage battery car.

With the above method of equalising the load, the part assigned to the engine becomes wonderfully easy and simple. The engine no longer is required to anticipate and provide for jumps in the load. It no longer has the responsibility of keeping the current pressure steady, or its supply adequate. Its load becomes so nearly uniform, that the first of the three requirements noted in the beginning, close regulation, is no longer of primary, but is of remote importance, while the second and third are at the same time greatly facilitated.

The slow speed, double valve engine, whose superior economy is conceded, now becomes not only permissible, but eminently practicable. We must also bear in mind that this method further favours economy by materially increasing the working capacity of a given plant, obviating, as it does, the necessity for the margin required under the old way, to compass the fluctuations of load. The method is, it is evident, applicable to all systems of the constant potential description, and is adaptable to circuits fed either direct or by feeders. The method can be applied to any existing plant without difficulty.

On following the connections in the diagram it will be seen that by turning the switch, S, to the right, instead of to the left, the compensating circuit is entirely disconnected, and the plant operates in the usual way, leaving the engine to bear the brunt of any fluctuations in the power consumed. The method admits of being modified and applied in an indefinite variety of ways, which cannot be detailed in this space.

In conclusion, it may be noted that accumulators have been for several years used as equalisers or regulators in connection with incandescent lighting circuits. The compensating action thus obtained, however, is much limited in scope and degree. The battery, when unaided, evidently cannot begin to assist the dynamo until the latter has actually wavered perceptibly in potential; and anything like a severe rate of discharge would at once lower the potential below that of the dynamo itself. Hence, even though, in such cases, large cells are used, to reduce the internal resistance and polarisation to a minimum, the compensating action is useful only for compassing relatively minute and brief fluctuations. By supplementing the E.M.F. of the accumulators, as is done in the method of the writer, the action is rendered independent of the size of battery used or of the extent and degree of the fluctuations to be compassed. Not only this, but the action does not depend on the loss of E.M.F. of the main dynamo. In fact, as we have seen, the method has for one of its objects to obviate any fall of voltage at the dynamo terminals, while it will easily, if desired, produce the contrary effect, or raise the voltage as the load increases, the same as is done by an "over-compounded" dynamo.

SOME FACTS CONCERNING GUTTA-PERCHA.

(*Continued from page* 737.)

THE investigations of the four official explorers—Seligmann, Wray, Burck, and Sérullas—agreed in the conclusion that if any of the more valuable varieties of the gutta-percha tree were to be perpetuated, cultivation must be immediately undertaken. These gentlemen differ, however, as to the name of the tree which ought to be propagated.

The *mayang taban dourrian*, of Singgaloungan, in Sumatra, was chosen by M. Seligman.

The *gutta taban mérah*, and the *gueutta taban soutra*, from Perak, in the peninsula of Malacca, were selected by Mr. Wray.

The *niatouh balam Tembaga*, from Ampaloo, Halaban, was considered the best by M. Burck.

M. Sérullas, owing to his having re-discovered the *Isonandra percha* or *Isonandra gutta*, of Hooker, in Singapore, naturally inclined to the propagation of this, the most valuable of all gutta-percha trees. No other *isonandra* (*palaquium* or *dichopsis*, the name matters little), combines the advantages possessed by this variety, whose gum has shown beyond all question or doubt the quality of stability. At the same time, it should be pointed out that other trees of the same species, found in various portions of Malaysia, and known under local names, such as those above-referred to, possess qualities not much inferior to those of the *isonandra gutta*.

In considering the regions natural to the gutta-percha tree, M. Sérullas indicates Malaysia as the only district, owing to its climatic conditions, where the best varieties are to be met with. This question is one of great importance, for upon it depends the cultivation of this plant in districts to which it is not indigenous.

M. Seligman adopts as the limits of the home of the gutta-percha tree the fifth parallel on each side of the equator. M. Sérullas, however, disagrees with this opinion, and suggests that the isothermal lines at six degrees north and south of the intersection in Malaysia of the geographical and thermal equators confine the zone of the guttas.

If the thermal equator be followed from east to west, starting from the Celebes, it will be found to traverse the island of Borneo, the south of the Malay peninsular, the north of Sumatra, Southern India, the Gulf of Oman, crosses Africa from the Red Sea to the Gulf of Guinea, strikes South America at the Guianas, and crosses it through Venezuela and Colombia to the Bay of Panamá; in the Pacific it leans southward to nearly the Salomon Islands, and after skirting the north coast of New Guinea returns again to Celebes. Along this track, and beyond the limits of its Eastern abode, the gutta-percha trees are represented by the *payena* in Southern India, the *bassia Parkii* in Africa, and the *Mimusops balata* in Guiana, Venezuela, and Colombia.

M. Sérullas indicates various of the French possessions in the East as being suitable for the cultivation of the *isonandra*, and going further afield states that the islands of Réunion and Maurice, in the Indian Ocean, are well adapted for its propagation. Indeed, the gardens in the island of Maurice possess plants of the *Isonandra gutta*, of Wight, which have flourished in a remarkable degree.

It is worthy of mention that in the Island of Celebes, a region to all appearance admirably adapted to the growth of the *isonandra*, not a single variety is found of any value. This is accounted for by the fact that the flora and fauna are Australasian, not Malaysian. But, adds the author, it is beyond doubt that the *isonandra* could be easily acclimatised there. M. Sérullas treats at some length the various terms employed by the Malays in describing different gutta-percha trees. We will select a few of the words more commonly used:—

Gutta; guétah (Sunda); *gota* (Batak); *gueutta* (Malacca); *gatta* (Macassar); *guitta* (Dyak). Signifies something sticky, like gum or bird lime.

Pertcha, pertjah, perdja, or peurtcha. Means rag or strip of cloth, and describes appearance of those gums which, previous to treatment in hot water, look like rags half reduced to a pasty semblance and hard pressed.

Balam; signifies a plant giving a milky sap; *Mayang*, the way certain flowers grow; *Kayou*, a certain wood.

Taban or *Teban*, though not really the same words, are used to describe a tree of good appearance, one worth cutting down, and are employed to describe a gum of first quality. *Tchaier* signifies liquid, and is applied to gums which coagulate slowly, and are therefore of little value for telegraphic purposes.

Boucou or *becou*, knot, lump, or ring, and is descriptive of those gums which coagulate quickly, forming a sort of excrescence at the incision made in the bark.

The two best varieties of gum are distinguished by a difference in colour, one called *mérah* (red) and the other white, known as *soutra* (soft or silky), so as to separate it from another white (*pouteh*) variety, but which is not good enough to be classed as *becou*, and is better than the *tchaier*.

The leaves also have their various descriptive terms. *Tembaga*, coppery, from the colour of the underside; *Tumba*, lance, from the shape; *Dourrian*, from the resemblance to the leaf of the fruit tree of that name. These are all indicative of good quality.

From M. Sérullas's statements, it would appear that a certain gum may be described as a sticky substance coming from a plant which gives a milky sap, produced by a tree of first quality, which flowers in a particular manner, the underside of whose leaves is coppery-

coloured, and whose gum, of a red colour, hardens quickly, or otherwise. Add to these definitions the innumerable names invented by the natives to satisfy the insistance of travellers who desire more precise information, and the difficulty of accurately discriminating between the varieties of percha, can be understood.

The method adopted by the natives of collecting the gums is far more disastrous to the good varieties of trees than to those of inferior quality. In the case of the latter, the sap coagulates but slowly, and an incision made in the bark allows a flow of some hours; a sufficient quantity can be thus collected without having resource to the felling of the trees. With the best kinds it is otherwise; the sap hardens almost immediately, and the incision is speedily closed, allowing but an infinitesimal amount of gum to exude. The plan pursued with these trees is as follows: A scaffolding is raised close to the tree about to be cut down, so as to support it in an inclined position when felled. This having been done, all the branches are lopped off except the lower portions of the larger ones. Incisions are then made completely round the trunk, commencing at the higher part, each about three-quarters of an inch broad, and at about 18 inches apart. It is evident that an enormous waste of gum takes place, for the bark remains untouched between the incisions. From the younger branches of a specimen M. Sérullas saw cut down, he obtained fifteen times greater a quantity of gum than collected by the natives from the trunk and large branches, and from the leaves at least twenty-two times that amount.

After the gum has been collected, it is immersed in hot water, kneaded several times, and finally taken out of the water at the end of five or six minutes. It is then spread in very thin transparent sheets. The mixture of other gums, of bark, wood, and stones, takes place subsequently, when the gum is reboiled for this purpose, which is effected in the proportions necessary in the particular case.

A popular error with regard to the Dyak collectors of gutta-percha is the superstition imputed to them of looking upon the period of full moon as the only proper time for collecting. As a matter of fact, says M. Sérullas, the period considered by them as the best is immediately after the rains, when the sap runs more freely. A curious circumstance connected with the *locale* of gutta-percha trees, and the observation of which frequently assisted M. Sérullas in his search for them, is the fact that where they grow no leeches are to be found, though the immediate vicinity, and the forest in every other direction, may actually swarm with them.

We will not follow M. Sérullas in his strictures upon the erroneous information as to the varieties of gutta-percha, the methods of collecting, the yield of sap, &c., published by various travellers, among whom Oxley, Lingard, O'Rorke, and Collins are mentioned as principal offenders. The matter is of a certain interest, but occupies too much space. Briefly stated, it would appear that limited observation, imperfect acquaintance with the locality, and a too ready acceptance of native statements, together with the confounding of the methods used in the collection and preparation of india-rubber with those adopted in the case of gutta-percha, may account for many of these errors.

Nor have we space in which to transcribe the author's remarks upon the conditions governing the Isonandra in a natural state, or on the question of transporting young plants to a distance from their native forests.

In *La Lumière Electrique*, of December 13th, these matters will be found fully set forth. We may, however, quote, as more particularly interesting, certain observations. It appears that the stumps of gutta-percha trees, after the trunks have been cut down, invariably show a speedy and vigorous growth of buds and shoots. This of course only applies to forests untouched by fire. On several occasions, M. Sérullas had the opportunity of observing the wonderfully rapid and healthy growth of cuttings under purely accidental circumstances. In one of these cases the cutting happened to be the trunk of a tree thrown across a stream, and forming portion of a bridge. As to the transport of young plants, the operation does not seem to have been so very difficult—warmth, shade, and moisture, their principal requirements in their native forests, appear, together with a sufficient protection of the roots, to be the chief essentials.

(*To be continued.*)

THE NEW ELECTRIC "MOOTER,"

AS DESCRIBED BY BIDDY M'CLURE IN AN OHM-LY EPISTLE TO "A FEIND IN THE OULD COUNTHRY."

(An electric motor has just been set up in a Brooklyn hotel for washing dishes."—*Daily Paper.*)

FORNINST the recait av this bit av a letther
Fram your dear furrin frind, lone Biddy M'Clure,
I'll just mintion me cowld an' me pay is aich betther
Since I wint for me misthress, an' thin for the door;
Shure meself cudn't stay wid her, she had such a way wid her—
Och! the month I was there was the tarrible jant!
So, musha! I sacked her, an' wid me characther
Crassed over the wather to Brookline beyant.

Good luck to her timper! no less to the bottle,
By raison av which the same fell on my pate!
For by the same token, I'm now in a hotel,
Wid the misthress loike honey, her tongue is that swate,
Och! it's here the work's aisy, acushla! the lazy
Colleens, shure they throubled the misthress a dale,
Till nothin' wud suit her but to sind for a *mooter*
For clanin' the dishes up afther aich male.

To describe it, acushla, 's beyand me—the sorra.
The loike in ould Oireland iver was sane!
Av yez putt a windmill in a washtub, begorra
There's a thrue-spakin' fortygraph av the machane!
Arrah! what wid the splashin' av wather an' smashin'
Av chinie that iligant mooter did make,
I wint undher the table, entoirely unable
To do half av me work for the howl av a wake!

Av ye ax *what compels it*, shure a saycret that same is
As meself ud be proud wid me own frinds to share;
But it isn't convaynient to spake what the name is
Wid the spaich av the counthry so furrin an' quare.
Shure, ye'll know quoite enough whin I say that the shtuff
Comes up through a hole in the tap av the flure,
An' av it's wance shpilt, tare an' ages! it's kilt
Entoirely thin is poor Biddy M'Clure!

But by this an' by that! it's meself won't decaive ye—
I'm aloive, an' its marrit I'll soon be to Pat:
Och, a mooter, alanna, 's a foine thing to lave ye
Convaynient to do a bit coortin' an' that!
For while wid the clanin' the mooter was strainin
Up shteps a foine paler wid helmet an' shtick;
Says he, "Och, ye craythur! yez two lips is swater
Than suggar!" says he—"let me tashte thim, avick!"

Thin forninst your recait av this bit av a gosther,
Av the mooter plays thricks, shure your Biddy'll be dead;
But av it behaves, an' me Pat's no imposther,
Thin praise to the Vargin! meself will be wed.
Wid Pat at the windie, an' this divil's own shindie,
Och, whirra! I'm ready to drop on the flure!
So whether I'm baried, or dacently married,
It's the mooter as done for poor Biddy M'Clure.

Ariel.

Electric Light in Liverpool.—A petition has been signed by occupiers of a certain district in Liverpool, requesting the Watch Committee to grant to the Liverpool Supply Company the necessary authority to enable them to lay electric lighting mains.

TELEGRAPH COMPETITION IN THE WEST INDIES.

THE West India Islands, once the scene of a thriving commerce, the resort of an energetic and wealthy community, have, during years of adversity, gradually sunk to a position not far removed from that lowest of all conditions—a negro's paradise. Fallen from their high estate, they are to-day chiefly associated with such petty transactions as the production of swizzle-sticks and guava jelly. The decadence which has overtaken this erstwhile prosperous region—we speak more particularly of the British possessions—and the hopeless stagnation into which affairs have drifted, combine to isolate these islands from busier communities, and fully justify the application of the words "the world forgetting by the world forgot."

All branches of industry seem to be pervaded with the lethargy resulting from years of inactivity, and the necessarily consequent indifference to progress and improvement has had such a widespread influence, that its effects have been evident in the paralysed condition of even telegraphic enterprise. We do not refer to the management, so far as efficient service and suitable tariffs are concerned, of that association which for nearly twenty years has held undisputed sway, but rather to the weakness and inactivity it has shown in allowing its opportunities to be irretrievably lost, and to the prolonged indifference in the conduct of its affairs, and the utter absence of prevision which have invited opposition schemes.

For a great change in the situation has recently taken place. This typical sleepy hollow, and its Rip van Winkle have been awakened to the fact that a French syndicate has discovered what others failed to appreciate, that the West Indies still offer a field to telegraph enterprise quite worth the cultivating.

This association, the Société Générale des Téléphones, founded in 1881, with a capital of 25,000,000 francs, was the prime mover in the establishment of the new submarine telegraph communications in the West Indies; and it is the chief factor in the organisation of the two companies, the Cie Télégraphique des Antilles and the Société Française des Télégraphes Sousmarins, whose names are more directly associated with the new cables. The first mentioned of these two companies was formed in 1884, with a capital of 200,000 francs, subsequently increased to 450,000; the second was founded in 1888, with a capital of 5,500,000 francs, afterwards increased to 11,000,000 francs.

In reviewing the work completed, in progress and contemplated, of these companies, we may neglect the Compagnie Télégraphique des Antilles, on account of the insignificance of its property. Before entering, however, upon a discussion of the aims and circumstances of the Société Française des Télégraphes Sousmarins, it will be necessary to revert, for a moment, to the Société Générale des Téléphones.

For many years the French Government has sought, whenever possible, to foster the manufacture of submarine cables in France, and to encourage French companies in submarine telegraph enterprise. The telephone company had become the proprietor of the well-known works of Rattier, at Bezons, near Paris; but the inland situation of this factory made it ill adapted for the manufacture and shipping of any considerable lengths of cable. With the view of meeting the wishes of the Government, and considering the probability that the telegraph companies, its *protégés*, would, in the course of time, largely extend their systems, the telephone company cast about for some seaport on the French coast suitable for the erection of a cable manufactory, and affording the necessary accommodation for cable ships. After the examination of several localities, Calais was finally determined on, and the factory at that place, immediately commenced, is now rapidly approaching completion.

An examination into the conditions attending the present development of telegraphic communications in the West Indies would appear incomplete without some reference to the concessions obtained by the Société Française des Télégraphes Sousmarins. The older ones, relating to cables already laid between Cuba, Haiti, Santo Domingo, Curaçao, and Venezuela, need not be recapitulated: we shall therefore confine ourselves to the more recent concessions:—

Martinique—Guadeloupe (laid).—Concession dated 7th June, 1889. For 25 years. Exclusive rights to land and work submarine cables. Annual subsidy granted by each island of £2,000.

Note (1). The agreement between the French Government and the West India and Panama Telegraph Company with regard to Martinique, expired on the 31st December, 1889; that relating to Guadeloupe terminates on 1st January, 1895. (2) The new concession stipulates that these islands shall be connected with some point on the present system. This in all probability will be either Santo Domingo or Puerto Plata, in the Republic of Santo Domingo. The payment of the subsidies must naturally mainly depend upon the establishment of this connection, by means of which the southern portion of the system is brought in communication with Cuba.

Guadeloupe — Marie Galante (laid). — Concession dated January, 1890. For 25 years. Annual subsidy granted of £400.

Cayenne (French Guiana). (To be laid shortly).—Concession dated 11th October, 1889. For 25 years. Exclusive rights of traffic. Annual subsidy granted of £4,000.

Note.—The concession stipulates that Cayenne shall be connected directly or indirectly with either Martinique or Guadeloupe.

Paramaribo (Dutch Guiana). (Laid 1890.) Concession dated 18th September, 1889. For 20 years. Exclusive rights for landing and working cables between Surinam and Cayenne, Venezuela, Curaçao, Haiti, Santo Domingo, Cuba, Martinique, Guadeloupe, and New York. Annual subsidy granted by Dutch colony of £2,400.

Brazil — United States. — Concession dated 10th January, 1890. For 35 years. Exclusive rights for transmitting, by one or more cables, directly or indirectly, all telegrams addressed to the United States which may be handed to the Brazilian Government telegraph stations, and exclusivity for all cable communications between Brazil and the United States.

Note (1). The Brazilian Government undertakes to afford the French Company special facilities for the interchange of traffic. (2) An earlier concession had been granted to the Pedro Segundo Telegraph Company, which, in an agreement with the Société Française, bound itself to connect this company's system with Brazil, and to obtain landing rights for it in the State of New York. (3) The concession granted to the Pedro Segundo Company lapsed owing to non-fulfilment on the part of the company.

Vizeu (Brazil)—Cayenne (French Guiana). (To be shortly laid.) This section is included in the above-mentioned Brazilian concession, which contains a clause to the effect that Vizeu, in the province of Pará, shall be connected to the French Company's system, by means of a submarine cable, on or before the 26th August, 1891.

Mole St. Nicolas—Port-au-Prince (Haiti). (To be shortly laid.) Concession dated 28th June, 1888. For 60 years. Exclusive rights for landing and working cables. Purchase of cable, by Haitian Government, by instalments extending over 2½ years, for £24,000.

Haitian Land-lines.—Concession dated 14th April, 1890. For 60 years. Exclusive rights in Haiti for constructing and working land-lines. The Government guarantees an annual interest of 8 per cent. on the capital expended in constructing certain lines, on the basis of £68 as cost per kilometre of line constructed.

North Coast of Cuba.—Concession granted by the Spanish Government for connecting, by means of submarine cables, the town of Santiago de Cuba with the principal ports on the north coast of the Island of Cuba.

Santo Domingo.—The exclusive rights for landing and working cables in the Republic of Santo Domingo expired on the 1st of August, 1890. A prolongation of these rights up to 1st August, 1892, has been obtained

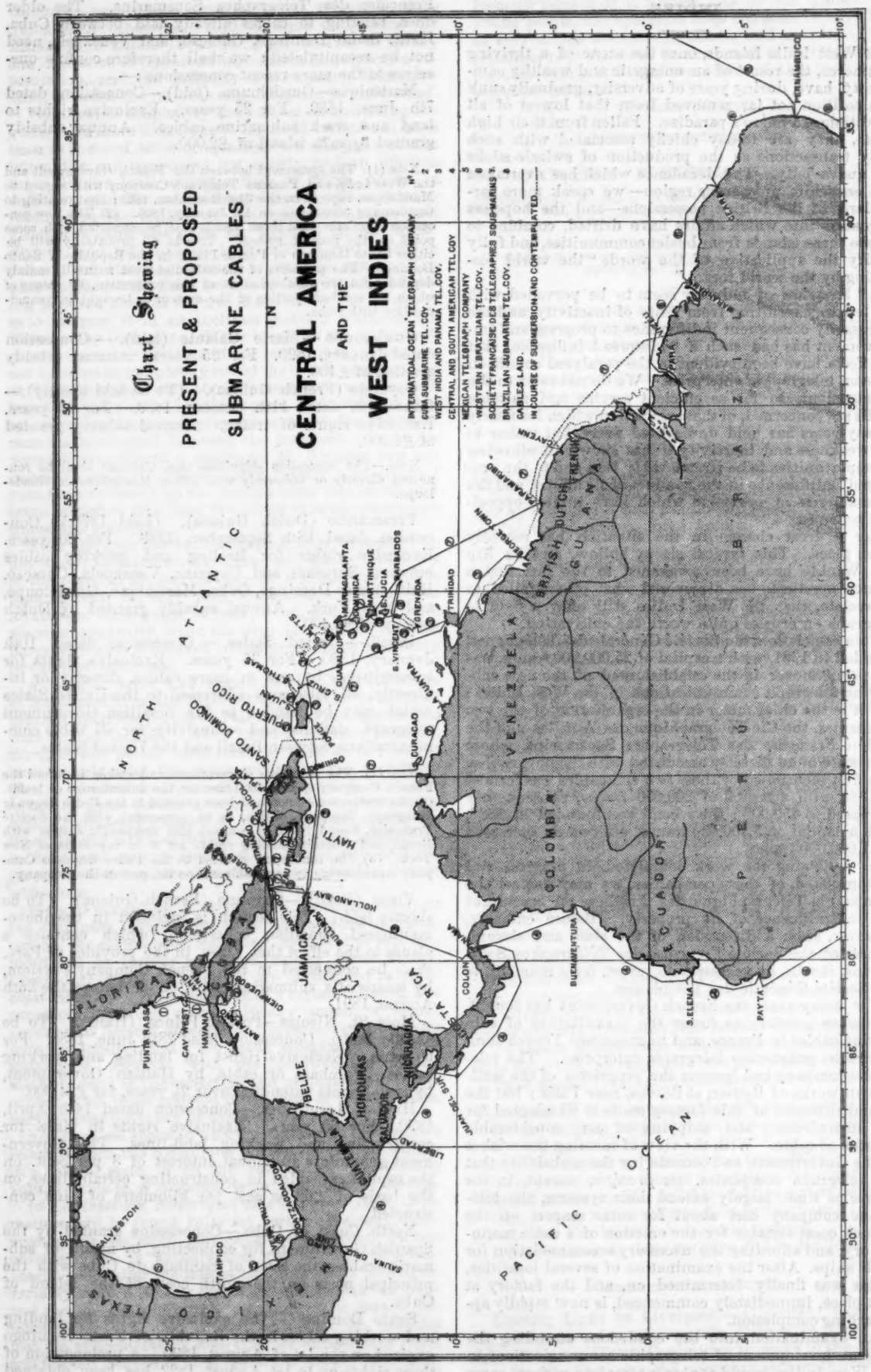


Chart Shewing
PRESENT & PROPOSED
SUBMARINE CABLES
IN
CENTRAL AMERICA
AND THE
WEST INDIES
INTERNATIONAL OCEAN TELEGRAPH COMPANY
CUBA SUBMARINE TEL. COY.
WEST INDIA AND PANAMÁ TEL.COY.
CENTRAL AND SOUTH AMERICAN TEL.COY
MEXICAN TELEGRAPH COMPANY
WESTERN & BRAZILIAN TEL.COY.
SOCIETÉ FRANCAISE DES TELEGRAPHES SOUS-MARINS
BRAZILIAN SUBMARINE TEL.COY.
CABLES LAID.
IN COURSE OF SUBMERSION AND CONTEMPLATED.
NORTH ATLANTIC
OCEAN
PACIFIC
OCEAN
VENEZUELA
COLOMBIA
ECUADOR
PERU
BRAZIL
BRITISH GUIANA
DUTCH GUIANA
FRENCH GUIANA
HAYTI
JAMAICA
FLORIDA
TEXAS
MEXICO
BELIZE
HONDURAS
NICARAGUA
COSTA RICA
SANTO DOMINGO
PUERTO RICO
CURACAO
TRINIDAD
BARBADOS
MARTINIQUE
GUADELOUPE
LONGITUDE WEST FROM GREENWICH

through the Société Générale des Téléphones, by the payment of £12,000.

The foregoing brief sketch, although not altogether complete, sufficiently indicates the position held by the French company; it is still undecided what route will be followed by the cable, or cables, necessary to connect Martinique and Guadeloupe with that portion of the system which gives an outlet from the West Indies *viâ* Cuba. The connection might be made either at La Guayra, at Curaçao, or at the port of Santo Domingo; in each of these instances the land-lines across the island of Santo Domingo would become a part of the main system. Or the cable, as will probably be the case, might be laid direct, from either Martinique or Guadeloupe to Puerto Plata, on the north coast of Santo Domingo, where the existing cables between that port and Cuba afford the desired communication.

The chart which accompanies this article will give a better idea of the situation than could possibly be obtained from a mere verbal description, and one cannot but wonder, on inspecting this chart and reviewing the programme of the French company, how it is that they have been allowed to occupy certain coigns of vantage.

A study of the circumstances would undoubtedly lead one to assume that the proper course for the company, which during nearly 18 years prior to the advent of the new undertakings, had held in its own hands the undisputed possession of the entire telegraphic communications in the West Indies, was to have secured itself in every feasible manner from the possible attacks of rival enterprises. The necessary precautions, however, were neglected, the opportunity was allowed to pass, and the Société Française, by establishing itself in Cuba, Haiti, Santo Domingo, Curaçao, and Venezuela, by ousting the West India and Panama Company from the islands of Martinique and Guadeloupe, by acquiring possession of the communications with the French and Dutch Guianas, and by securing an entry into Brazil, has obtained a permanent footing, not, indeed, without a struggle, in what should have been the elder company's reservation.

The Cuba Submarine and the West India and Panama Companies, awakened too late to the gravity of the situation, vigorously opposed the landing of the French cables on the island of Cuba, and for some time succeeded in hindering the opening of those lines to the public, maintaining that the wording of the concessions granted by the Spanish Government distinctly included exclusive landing rights in Cuba. On the advice, however, of the colonial section of the Council of State in Madrid, a Royal decree was promulgated authorising the French companies to land their cables in Cuba. The decree was dated January 17th, 1889, and the lines between Haiti and Cuba were opened for international traffic on February 7th of the same year. We imagine that the French company has, for this decision in its favour, in a great measure to thank the feeling, which of late years has become very noticeable in Madrid, that the West India and Panama Company has not fulfilled its engagements, nor adhered to the intention of the concession granted it in 1868. It is not our purpose, at least for the present, to discuss the merits of the case, but some mention of the circumstances seems necessary, more particularly as this very cable between Haiti and Santo Domingo is the keystone of the position, so far as the West India and Panama Company and the French Association are concerned.

The French company has secured, either by its own concessions or by alliance with friendly associations, cable communication between Cuba and Brazil; a new route between South America and the United States and Europe has thus been opened, and the stations on this new line will have duplicate communications with the outside world. Although this advantage is great, it is somewhat diminished by the fact that the Société Française depends, at present, for an outlet upon companies which have hitherto not shown themselves very favourably disposed towards the new enterprise.

At the Cuban extremity of the French system, communication with North America and Europe is obtained through the Cuba Submarine Company's cables along the south coast of Cuba, and the International Ocean Company's lines between Havanah, Key West, and Florida: at Vizeu, the Brazilian termination of the system, a route to Europe is opened either *viâ* the Brazilian Government land lines to Pernambuco, or through the Western and Brazilian Company's cables between Pará and Pernambuco, at which latter place the Brazilian Submarine Company's trans-Atlantic cables terminate on the South American coast.

How much importance may be attached to the concessions granted to the French company for the cable along the north coast of Cuba is yet to be seen; under existing conditions such lines could only serve as local feeders to the general system, and the French company may have to push on its connections from its West Indian system, either direct to the United States, or may even be compelled to seek an outlet *viâ* St. Pierre, Miquelon, which place is directly connected to France by a transatlantic cable.

Far more menacing, however, is the position of the Société Française in the extension southwards of its cables. We refer to the circumstances which have permitted this association to continue its lines from the Guianas to Brazil, and it seems a very extraordinary omission that the gap between Demerara and Pará has not long ago been bridged over with some efficient means of communication. It is manifest that such a connection would have been most advantageous to the West India and Panama Company, and some exceedingly strong reasons must exist, other than difficulties in obtaining concessions, for neglecting so important a link. Perhaps the presence on the board of the West India and Panama Company of directors of the Western and Brazilian, and Brazilian Submarine companies, may in some measure, account for what may be described as remarkable apathy. We will not dwell, however, on this more personal portion of the subject, since it does not come within the scope of this article to discuss why, or how, an individual can attempt to serve two masters whose interests appear to be diametrically opposed.

An attempt was made in 1874 to connect Brazil with the West Indies. Cables were laid between the Guianas and Pará by the long defunct Central American Telegraph Compnay; but as a means of communication these lines were literally ephemeral, lasting but a day. It is to be remarked that the West India and Panama Company, at the time, or shortly after, these cables were laid, entered into negotiations for their purchase, if, indeed, it did not become actually the proprietor of them. It is also worthy of note that the arrangements entered into between the West India and Panama Company on the one hand, and the Brazilian Submarine and Western and Brazilian Companies on the other, seemed to result in the utter collapse of the Central American cables. We are ignorant as to what attempts, if any, may have been made to repair these cables, but this much is certain, they were speedily abandoned.

In considering the results which are likely to attend the establishment of the cables of the French companies, certain important factors must not be lost sight of.

The concessions granted by the Brazilian Government to the Société Française will hinder, for the time being, the organisation of a completely independent cable route between Brazil and the United States. The American Government, as a rule, does not care to sanction the landing of cables on American territory by an association which, from the exclusive rights it might have acquired, could oppose obstacles, in another country, to the landing of cables by any American citizen. It must be remembered that reciprocity is a leading feature in American politics. It is not probable, however, that the French company will, on account of this temporary difficulty, be long debarred from that outlet which is of so vital importance to its interests. Sooner or later it is certain to find means for obtaining the communication necessary to guarantee the efficiency of its system.

Although, as above set forth, the French Company is, for the time being, hampered in its action, a distinct gain to it in another direction fully compensates for that temporary inconvenience. The struggle for the possession of Brazilian and other South American traffic has assumed an acute phase, and energetic measures are being undertaken by rival enterprises on both sides of the South American continent to secure this traffic. The Western and Brazilian Company on the east coast is in strong competition with the Central and South American Company on the west coast; and when the French West India lines are completed to Brazil it is fair to assume that the Western and Brazilian Company will find it to their advantage to work in accord with the new enterprise. It is evident that the French cables offer a more natural route for telegraphic communications between North and South America than the existing one by which this traffic is under the necessity of twice crossing the Atlantic. That the importance of the commercial relations between South America and the United States fully justifies the establishment of the new communications, is shown from the estimated value of South American telegraph business, which may be placed at about £300,000 per annum. It is probable that of the messages represented by this amount a satisfactory proportion will be diverted to the French cables.

The Submarine Cable Systems of the Compagnie Télégraphique des Antilles and the Société Française des Télégraphes Sousmarins.

From.	To.	When laid.	Approximate length N.M.
Aguadores, Cuba...	Caimanera, Cuba	1888	50
Caimanera, Cuba...	Môle St. Nicolas, Haiti	1888	126
Môle St. Nicolas, Haiti	Port au Prince, Haiti	To be laid shortly	106
Môle St. Nicolas, Haiti	Puerto Plata, Santo Domingo	1888	188
Puerto Plata, Santo Domingo	San Domingo, Santo Domingo	Land-line 1888	95
San Domingo, Santo Domingo	Santa Ana, Curaçao	1888	453
Santa Ana, Curaçao	La Guayra, Venezuela	1888	163
Puerto Plata, Santo Domingo	Fort de France, Martinique	To be laid shortly	670
Fort de France, Martinique	Pointe à Pitre Guadeloupe	1889	118
Pointe à Pitre, Guadeloupe	St. Louis, Marie-Galante	1889	25
Fort de France, Martinique	Paramaribo, Dutch Guiana	1890	685
Paramaribo, Dutch Guiana	Cayenne, French Guiana	To be laid shortly	252
Cayenne, French Guiana	Vizeu, Province of Pará, Brazil	To be laid shortly	575

So far as the Brazilian traffic with the United States is concerned, the West India and Panama Company can hope for no share; but it is otherwise as regards the Cuba Submarine and the International Ocean Telegraph Companies. It is beyond question that these associations have everything to gain from friendly alliance with the new enterprise, since their systems would directly benefit by such traffic as might come to them from the French cables; and, further, these amicable relations might secure immunity from the consequences to be expected by the establishment of competing lines. Let these companies take warning from the isolation which the West India and Panama Company has brought upon itself.

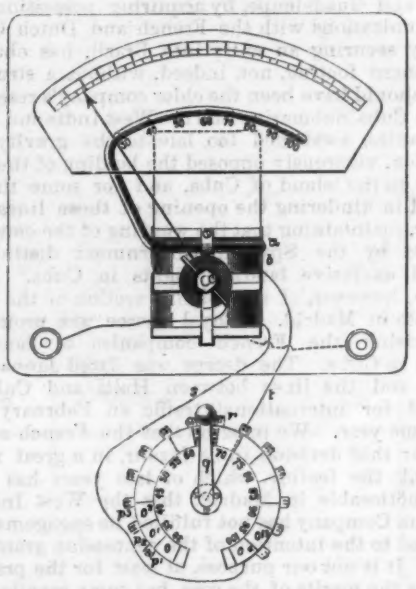
The accompanying table showing the cables of the French companies laid, in progress, and contemplated, may assist to an appreciation of the situation.

WESTON'S TEMPERATURE REGULATOR FOR MEASURING INSTRUMENTS.

AMONG the errors to which electric measuring instrumects are subject is that due to the heating of the coils by the passage of the current. This evidently increases their resistance, and changes the value of the readings indicated. To avoid this as much as possible recourse is had to wire having as low a temperature co-efficient as possible; but such wire of German silver or platinoid is very expensive when the finer sizes are employed. and hence it becomes desirable to retain copper wire if some means can be provided for correcting the error due to the change in resistance resulting from temperature variations.

Realising this disadvantage, says the *Electrical Engineer*, N.Y., Mr. Edward Weston, Newark, N.J., has recently brought out an important addition to his well-known and admirable instruments, consisting of a temperature regulator, but which is, of course, applicable to instruments wound with whatever kind of wire.

In order that variations in temperature may be recognised, Mr. Weston provides a thermometer, *m*, the mercury bulb of which is elongated, and is curved and fastened directly against the exterior of the coil. The thermometer tube is bent, as shown, and arranged upon the scale plate, and in a curve parallel to that of the scale markings. By means of this thermometer the temperature of the coil is shown upon the same scale plate as the regular indications of the instrument.



A series of contacts, o to o^{14}, insulated from one another, are arranged in a circle, and between the successive contact plates are included resistance coils, p^1, p^2, p^3, &c. Pivoted concentrically with the circle of contact plates is a switch-arm, q, having contact springs bearing upon the surface of the contact plates, o.

This device is interposed in the circuit of the fixed coil, and is connected to it by the wires, s, t. The contact plates, o, o', &c., are marked to correspond to the thermometer scale. Thus the contact plate, o, is marked "30" to correspond to the 30° mark of the thermometer, the contact plate, o', corresponds to the 35° mark of the thermometer, and so on, the contact plate, o^{14}, corresponding to the 100° mark. When the arm, q, is placed on the contact plate, o, it will be evident that the current in the instrument then passes through all the resistances, p, p^1, p^2, and, p^3.

Suppose, for instance, that this is the starting point of temperatures, and that the heat of the coil increases, so that the thermometer shows a temperature of 65°. This means an increase of resistance in the coil due to the 65° difference of temperature. In order to compensate for this the switch arm, q, is moved around until its contact spring rests on the plate, o', marked "65." Seven resistances, p, p', will thus be thrown out of the circuit, and as each resistance corresponds to the increase of resistance in the coil due to the elevation of 5° of temperature, it follows that by throwing out seven of these resistances we have exactly compensated for the increased resistance of the coil due to its increased heat.

In practical operation, therefore, it is simply necessary to note the indication of the thermometer, and place the arm, q, on the contact plate mark corresponding to that indication, in order to keep the resistance of the circuit in the instrument uniform.

ELECTRIC RAILWAYS.*

By THEO. P. BAILEY.

THE practical development of electric street railways, and their commercial perfection, may properly be said to have been accomplished within two years, and yet there are at the present time 246 electrical street railway plants either in operation, or ready to be put in operation, within a short time. Two years ago, and even within the past 12 months, we were asked many questions by intending purchasers, which to-day are not even hinted at. Some of the prevailing questions of that age were:—

Can electricity be applied in our case?

Can a street railway, equipped with electricity, be made a practical and commercial success?

What will be the life of the apparatus?

What will it cost to keep the apparatus in repair?

Is not the current dangerous to human life?

Will it not ruin the watches of passengers?

The street railway people to-day appear to have become thoroughly satisfied on these questions, and consider it an idle waste of time to discuss them further. But in lieu they ask us this: "How soon can you furnish the equipment for our road, and what will it cost?" Just think of this statement for a moment: Two hundred and forty-six electrical railways in operation, embracing 2,024 miles of track, and 3,830 motor cars, requiring in the neighbourhood of 6,400 motors with a probable aggregate capacity of 174,435 horse-power, employing an electrical generating capacity at the station of about 94,880 horse-power! Did any one of you anticipate two years ago that such a condition of facts could under any circumstances be realised within so short a time? I attribute this wonderful development and success to the following causes:—

First, the full practicability of the undertaking; second, the wonderful earning capacity of the electrically equipped car as compared with the horse car; third, a determination on the part of the electrical manufacturers to meet the requirements of the railway companies; and fourth, the untiring and undefatigable efforts of the exploiter or salesman.

Among the numerous and possibly fatal objections raised to the use of electricity, when it was proposed to apply it to street car propulsion, was that grades exceeding 5 per cent. could not be mounted. But experience and practice have shown that grades as high as 14 per cent. can be ascended with reasonable safety and satisfaction. There is a grade of 13 $\frac{5}{10}$ per cent. at one point on the line of the street railway at Lynn, Mass., over which 16-foot cars equipped with two 15 horse-power motors are in daily and successful operation. At Milwaukee a grade of 10 $\frac{3}{10}$ per cent., 430 feet long, is encountered and successfully operated over by 20-foot cars, equipped with two 15 horse-power motors, the total weight of car complete with passengers being 10½ tons. A similar grade is met with at Newport, R.I., and Omaha, Neb., and numerous grades almost as heavy are seen in the electric railway systems at Des Moines and Davenport, Ia., and Kansas City, Mo.

At the present time there are as nearly as can be ascertained 957 street railways in the United States and Canada. Of this number 589 are operated by horses; 49 by cable; 248 by electricity; 73 by steam.

It is estimated that the total money value of these combined properties is $164,400,000, proportioned as follows:—Horse railways, $58,900,000; cable railways, $49,000,000; electric railways, $49,200,000; steam railways, $7,300,000.

These figures are at best only approximations, as it has been found impossible to secure absolutely accurate information.

This combination of motive powers is doing service over or upon 8,818 miles of track as follows:—Horses, 5,713; cable, 527; electric, 2,024; steam, 554.

I find that the cost per car mile for the several methods referred to, including all operating expenses and fixed charges, other than interest, is as follows:—Horses, 5·7 cents; cable, 2½ cents; electric, 2·2 cents; steam, 5 cents.

A large majority of the street cars equipped electrically at the present time are mounted upon a single truck, to which are attached one or two motors, as required by the conditions existing in each particular case. The lightest equipment with which I have had to do has been a single 15 horse-power motor upon one truck; and the heaviest equipment has been two 15 horse-power motors upon one truck. The tendency, however, at the present time seems to be in the direction of longer cars, double trucks, and heavier motors. This action is prompted very largely, no doubt, by the sad and costly experience of some companies where trailers were used in connection with the motor car; serious accidents, and in some cases death, having resulted from injuries sustained by passengers in falling between the motor and trail car while passing from one to the other.

The use of the longer car with double trucks is recommended further as a means of comfort to the passengers, and also on account of the longer life of the car and its equipments. This style of car is, of course, unattended by the oscillating motion found in the shorter car with a single truck. Where the shorter motor car is used with a trailer experience shows that there is a great loss in wear and tear by reason of the cars jamming together when the brakes are applied. This fault is obviated in the longer car, and while its seating capacity may not be equal to that of two shorter cars, it is approximately so. It is claimed further for the longer car with double trucks that less energy is required to operate it; also that it saves the expense of one man, decreases the expense of maintenance, and increases the facility for handling passengers.

In treating of the subject of electric railways from a commercial standpoint, I have considered only that branch designated as the single wire overhead system.

For obvious reasons too much care cannot be observed in planning and locating the various factors which go to make up a complete electric railway plant. Assuming that the railway company has secured the desired franchises and rights of way, has laid out its lines of track so as to avoid all excessive grades, and yet reach the attractive and important points of the town or city, and that it has been fortunate enough to make proper selection of its apparatus, the next important work for it to determine is the location and arrangement of its power station. The selection of a site should be made with reference to obtaining the best facility for handling coal and securing water, and also with reference to the electrical centre of the railway system, in order to realise the highest degree of economy in the operation of the plant. The arrangement of the power station is equally as important as its location, with regard to handling the work with the least cost for labour. The selection of the steam plant is a matter of great importance, and should be left with a thoroughly competent and reliable engineer to determine what particular type of engine, boiler, &c., should be used; and the matter should be left under his direction and care until the installation has been completed. It is manifest that in so doing serious blunders will be avoided. I do not think it can be justly claimed that the railway companies have been too liberal in the amount of horse-power purchased for the operation of their generators. In order to secure the best results, with reference to reliability of service, the horse-power of the engine should be at least 20 per cent. greater than that of the generator which it drives, in order to provide for loss in transmission and excessive loads which are thrown on the generator by reason of a large number of cars starting at the same time; or on account of a ground being accidentally thrown upon the line. The steam plant should be so arranged and connected to the generators that either engine or generator may be readily interchanged; and the arrangement of the engines and generators should be made with reference to future extensions. The switchboard containing the indicating and regulating devices, should be located so as to be most accessible to the attendant.

Both the power and electrical plant when complete and ready for operation, should be placed in the hands of men of experience and learning in these departments, in order to ensure reliability of service, and the greatest economy in operation and maintenance. I would rather provide in advance for the expenditure of $1,000 or more in this department than to run any risk of having to pay out four times that amount in repairs and losses occasioned by mistakes of incompetent men.

The location and arrangement of the car house is a question of considerable importance, and open to serious mistakes growing out of bad location or improper interior arrangement. Some advantages are secured by locating the car house immediately adjacent to the power station. In this case it may be heated with the exhaust steam from the power plant, and the services of *employés* utilised in both buildings, and repairs to apparatus concentrated at one point. The car house should be provided with suitable pits for the inspection of the motors, and also have proper accommodations for cleaning the car bodies. If the car house is to accommodate more than 20 or 25 cars, it should be provided with running and turning tables, and should also have more than one exit.

I cannot pass from the question of inspection of apparatus without emphasising the extraordinary importance of having this work done thoroughly by competent and faithful attendants. With electrical apparatus of standard makes we can reasonably expect that a motor car sent out in the morning for the work of the day, having passed through proper inspection, will perform its duty with a degree of certainty that need leave but little, if any, cause

* Read before the Chicago Electric Club, November 17th, 1890.

for anxiety. This feature is, perhaps, the most difficult one to impress upon the management of electrical railway companies, more especially where such railways have been converted from animal power. If railway companies will guarantee that degree of care and watchfulness in the operation of their motors indicated above, we take practically no chances by giving them the broadest guarantees as to the durability of the apparatus, and the cost of maintenance and repair.

It is apparent that in the overhead construction the highest degree of care should be exercised as to its details and arrangement, for this part of the equipment is constantly open to criticism. We cannot blind our eyes to the fact that serious, and, in some instances, fatal criticism has been made to this work. We must all avail ourselves of the experience which has attended our efforts, and see to it that our overhead construction is not in any case, or for any reason, slighted.

I think an iron pole 28 or 30 feet long, made in three sections of extra strong pipe 6 inches in diameter at the base, and 4 inches at the top, provided with wheel base and insulated cap, presents the most sightly appearance on the street, and forms the most substantial construction that can be had. Next in reliability and appearance is an octagonal pole of Southern pine suitably painted; and, lastly, and the pole most commonly used, the Western Union standard. These poles should be properly set with sufficient rake to allow of sustaining a strain of at least 900 lbs. To these poles should be attached by means of eye-bolts a galvanised steel wire having a diameter of at least ·204 of an inch, and drawn taut so that the poles will come to a perpendicular position. To these span wires there should be attached a suitable insulating device over the centre of each track with proper attachments for suspending the trolley wire. This insulating device should be small in its construction, consistent with strength and high insulation, and the insulating material formed in such manner that it will in itself constitute a protection against moisture. The trolley wire should, in my judgment, be at least ⅜ths of an inch in diameter, considering the objection that is raised to the multiplication of wires in the streets. This wire should be hard-drawn copper in lengths of at least one mile each. In this case, the number of splices is reduced to a minimum, and by means of a suitable splicing ear the joints can be neatly, perfectly, and securely made.

Where the streets are of a width of at least 60 feet from curb to curb, it is regarded as thoroughly safe and practicable in cases of double track roads to place the poles in the centre of the street between the tracks, and whether these poles be made of iron or of wood of octagonal shape, I consider that this arrangement presents the best form of overhead construction that can be secured.

When a conduit can be constructed that will permit of the safe, reliable and economical operation of street railways by means of electricity, we will all rojoice, and be glad. If its first cost can be made sufficiently reasonable to permit its use in cities of, say 50,000 inhabitants, it will be a magnificent achievement, and one that will surely bring its just reward to the successful inventor.

This thought is not prompted by reason of any vexatious troubles or annoyances which have occurred in the operation of the overhead system, but wholly on account of the objections which have been raised to the rapid multiplication of poles and wires in the streets, occasioned by the remarkable development and progress of the electrical science.

One of the prominent electrical companies is, and has been for some time, carrying on extensive and elaborate experiments with conduits, but have not, I believe, fully satisfied themselves of the commercial success of their latest undertaking.

I find little or no objection to overhead wires in place of less than 50,000 inhabitants. For this reason, and the fact of its low first cost, the overhead system will no doubt continue to be used in such places for some time to come, regardless of developments in the conduit system.

One of the most important features of an electric railway system is the track or road bed. My experience has been that sufficient attention has not been given to that part of the equipment, especially until very recently. The track should be constructed of a good form of girder or "T" rail, weighing 54 lbs. or 40 lbs. per yard respectively, and should be attached securely to suitable ties placed not more than 2½ feet apart. It should be well ballasted, and where crossings are made over other tracks solid castings should be used in order to prevent the jolting and jarring which occurs when passing over them. The rails should be kept as clean as possible where they are used as a part of the return circuit. In order to use the rails of the track in completing the return circuit they should be firmly connected together by a copper wire in addition to the ordinary fish plates, and in certain cases, depending wholly upon the length of the line, number and extent of grades, and number of cars and amount of traffic, there should be used a supplementary copper wire, the size of which must depend upon the conditions just named. It is asserted by some electricians that the efficiency of the return circuit is increased in all cases by the use of a supplementary wire; but my experience has been upon small roads where the grades and traffic are light, that satisfactory and economical operation is secured where the supplementary wire is omitted.

Some of the essential requisites of an electric motor car are proper controlling mechanism and reversing switch for controlling the speed and direction of the car, a lightning arrester and multiple fuse box. It should also be provided with suitable life guards, bells, and head lights. The wheels of the car should in my judgment be at least 33 inches in diameter and weigh 300 lbs. each. This will give increased adhesion and allow the motors to be raised sufficiently high from the ground to prevent practically the possibility of its being injured by striking obstacles between the rails.

Increased speed with a very slight increase of power will result by the use of the 33-inch instead of the 30-inch wheel.

The possible speed of a car equipped electrically is measured only by the limit of safety. The regulation speed in the majority of places is twelve miles per hour, and the average mileage per car per day about 115. It is well known that upon well regulated steam railroads the locomotives rarely make a continuous run of over 100 miles per day; and considering the extraordinary care that is given to them, and remembering in the same connection the very slight degree of care given to the average electric street railway motor, I think the latter is entitled to a very handsome compliment for the good service it gives us; and when you know that the best average mileage that can be made by a car propelled by the Kentucky horse or Texas mule is 60 miles per day, and even in doing this it is necessary to make at least four changes per day, I think you will admit that the electric railway motor is doing most admirable service.

The smallest town in the United States which has an electric street railway in operation is Southington, Conn., with a population of 5,400. Two cars are in service over two miles of track, and the average daily receipts are $9.00 per car. The power for the operation of this road is furnished by the local lighting company, and costs $1.25 per car per day. The largest electric railway is at Boston, Mass. The entire system comprises 284 miles of track, sixty of which are electrically equipped, and there are 312 motor cars in operation. During the month of August they had 300 motor cars in service, making a total mileage of 384,700,000. The mileage of the tow cars 59,948,000; making a total car mileage of 444,648,000. From August 10th to August 16th, 700,000 passengers were carried by these cars without a single delay. In the month of September, 312 motor cars were in operation, making a mileage of 343,466,000, and the mileage of tow cars 56,047,000, making a total car mileage of 399,513,000. The following is a statement of one road:—

Average number of motor cars run per day ...	20
Average number of trail cars run per day ...	0
Average number of hours per car in service per day	18
Average number of miles per car per day ...	108
Electromotive force	500
Average ampère readings taken hourly ...	122
Average electrical horse-power	81·8
Average electrical horse-power per car ...	4 9
Number of passengers carried per day ...	11,060
Number of passengers carried per car per day	553
Cost of operating per car mile	$·0616
Receipts per car mile	·2560
Cost of operating per car per day	6 65
Receipts per car per day	27·65

Most flattering testimonials have been received from railway companies who have adopted the electric system, and while they express their absolute satisfaction with the new motive power they also state, that the earning capacity of their road has been materially increased, In some cases the increase is given as high as 400 per cent., and in others as low as 50 per cent., but in no case that I can now remember has the increase been given lower than the amount last stated.

Inquiry is sometimes made as to whether a motor car can be safely and reliably operated without a conductor. The present form of trolley and overhead construction readily permits of this; but I do not regard it as practicable or advisable except in the smaller places where the business of the road will not justify the expense of a conductor. I am familiar, however, with a number of roads in towns or cities having a population of less than 30,000 where the car is in the exclusive charge of the motorneer, and no trouble is experienced in its operation. With a good track there is little, if any, possibility of accident when proper care is exercised in taking curves and switches. Where the business will warrant the expense, however, there should be a conductor with every car or train.

We cannot overlook the fact that there are still some complaints of excessive cost for repairs and maintenance of the electrical apparatus, but I insist that the responsibility for this condition does not rest altogether with its manufacturers. The managers of these electric roads must appreciate that they are exacting a greater mileage duty of their motors than is expected of the ordinary railroad steam engine and under conditions manifestly more unfavourable. If they will admit this, and see to it that their tracks are put in good order and so maintained, and the same degree of care and attention given to their motors that is given to the steam engine, I am satisfied they will have little to complain of. How rarely do you find an electric motor operated on a track like that prepared for the steam engine? And how seldom do you find a man in charge of the motor car who has the intelligence, training and experience of the steam engineer?

Several railway companies which adopted the cable system before the possibilities of the electric system were fully appreciated or understood, are now seriously considering the complete displacement of that system and the substitution of electricity in its stead. I was recently informed by the president of one of the electric railway companies, whose line is a competitor to a cable road, that the latter company, feeling keenly the effect of the

competition of the electric system had about concluded to reduce the fare on their road to 4 cents per passenger. Before this action takes place, however, I have no doubt that some bright representative of the electric system will persuade our cable friend to join the procession of progress, abandon the cable, welcome and adopt electricity as the motive power, and thus preserve the independence and stability of his street railway system.

There is no system or method of rapid street transportation that is so universally popular as the electric system; its wonderful flexibility is unparalleled in the history of street railways; capable of moving in either direction with equal facility, its value is materially enhanced from the standpoint of safety. Its first cost is about the same as for the animal system, and considerably less than the cable system. Knowing what the possibilities of the electric system are, and how cheaply it can be maintained and operated under proper conditions, I think we will see street railways thus equipped in many towns of a population not exceeding 10,000, and in some cases even less, and at a period not very remote.

I have previously alluded to the remarkable growth of the electric railway business, and given some reasons for it, but I do not feel that full justice has been done to the pioneers—I mean the manufacturers of the apparatus. When you consider what they had to do, and what they did do, in order to inspire confidence in the undertaking, I think you will all agree with me that they have merited even greater success than has attended their efforts, if that be possible. Contracts with all sorts of guarantees were made, long trial periods were given, the cost of maintenance guaranteed to be less than for the same number of cars operated by animal power, the current guaranteed not to be fatal to human life, and the system warranted to work in a thoroughly practical and successful manner, with a general and sweeping provision that in case of failure in any of the guarantees, the railway company could, at their option, throw the apparatus out, and assess the electrical company any damages which they had sustained by reason of the alleged experiment. Was there ever a new industry vouched for so absolutely by its projectors? Had the electric companies been less liberal with their guarantees, and not exhibited such a marked degree of confidence themselves, we undoubtedly would have been able to-day to count the number of electric railways by tens instead of by hundreds, for it is but a short time since the financial world has given its unqualified indorsement to the system. Bankers and trust companies took no part in formulating public sentiment or confidence in this matter. The undivided burden was assumed and borne by the electrical company, and not until they had fulfilled their numerous guarantees faithfully and well, and demonstrated beyond all peradventure the full and complete success of the electric street railway was the moneyed man or corporation willing to assume any hazard or risk. How the conditions have changed in two short years! Every principal city in the United States now has its electric street railway; full confidence has been established, and unreasonable guarantees are no longer required.

In closing, permit me to offer this prediction, that within a few years, surface and elevated railways operated by animal, cable, or steam power, will be numbered with the events of the past, and electricity, with all its beautiful attributes, in all its grandeur and magnificence, and in the full measure of the wide range of its possibility, will claim supremacy in the broad realm of street railway transportation.

THE ELECTRO-MAGNET.*

By Prof. SILVANUS P. THOMPSON, D.Sc., B.A., M.I.E.E.

(*Continued from page 747.*)

Effect of Using Coned Plungers.

But now if, instead of employing a cylindrical core, you employ one that is pointed, you find this completely alters the position of the maximum pull, for now the point is insufficient to carry the whole of the magnetic lines which are formed in the iron rod. They do not come out at the point, but filter through, so to speak, along the sides of the core. The region where the magnetic lines come up through the iron into the air is no longer a definite "pole" at or near the end of the rod, but is distributed over a considerable surface; consequently when the point begins to poke its nose out, you still have a larger portion of iron up the tube, and the pull, instead of coming to a maximum at that position, is distributed over a wider range. I am now making the experiment roughly with my spring balance and a conical plunger, and I think you will be able to notice a marked difference between this case and that of the cylindrical plunger. The pull increases as the plunger enters, but the maximum is not so well defined with a pointed core as it is with one that is flat-ended. This essential difference between coned plungers and cylindrical ones was discovered by an engineer of the name of Krizik, who applied his discovery in the mechanism of the Pilsen arc lamps. Coned plungers were also examined by Bruger. In fig. 63 are given the curves that correspond to the use of a coned iron core, as well as those corresponding to the use of the cylindrical iron rod. You will notice that, as compared with the cylindrical plunger, the coned core never gave so big a pull, and the maximum occurred not as the tip emerged, but when it got a very considerable way out on the other side. So it is with both the shorter and the longer coil. The dotted curves in fig. 64 represent the behaviour of a coned plunger. With the longer coil represented, and with various currents, the maximum pull occurred when the tip had come a considerable way out; and the position of the maximum pull, instead of being brought nearer to the entering end, with a high magnetising current, was actually caused to occur further down; the range of action became extended with large currents as compared with small ones. Bruger also investigated the case of cores of very irregular shapes, resembling, for example, the shank of a screw-driver, and found a very curious and irregular force-curve. There is a good deal more yet to be done, I fancy, in examining this question of distributing the pull on an attracted core by altering the shape of it; but Bruger has shown us the way, and we ought not to find very much difficulty in following him.

Other Modes of Extending Range of Action.

Another way of altering the distribution of the pull is to alter the distribution of the wire on the coil. Instead of having a coned core use a coned coil, the winding being heaped up thicker at one end than at the other. Such a coil, wound in steps of increasing thickness, has been used for some years by Gaiffe, in his arc lamp; it has also been patented in Germany by Leupold. M. Trève has made the suggestion to employ an iron wire coil, so to utilise the magnetism of the iron that is carrying the current. Trève declares that such coils possess, for an equal current, four times the pulling power. I doubt whether that is so; but even if it were, we must remember that to drive any given current through an iron wire, instead of a copper wire of the same bulk, implies that we must force the current through six times the resistance; and, therefore, we shall have to employ six times the horse-power to drive the same current through the iron wire coil, so that there is really no gain. Again, a suggestion has been made to enclose in an iron jacket the coil employed in this way. Iron-clad solenoids have been employed from time to time. But they do not increase the range of action. What they do is to tend to prevent the falling off of the internal pull at the region within the mouth of the coil. It equalises the internal pull at the expense of all external action. An iron-clad solenoid has practically no attraction at all on anything outside of it, not even on an iron core placed at a distance of half a diameter of the aperture; it is only when the core is inside the tube that the attraction begins; and the magnetising power is practically uniform from end to end. Last year I wished to make use of this property for some experiments on the action of magnetism on light, and for that purpose I had built, by Messrs. Paterson and Cooper, this powerful coil, which is provided with a tubular iron jacket outside, and a thick iron disc perforated by a central hole covering each end. The magnetic circuit around the exterior of the coil is practically completed with soft iron. With this coil, one may take it, there is an absolutely uniform magnetic field from one end of the tube to the other; not falling off at the ends, as it would do if the magnetic circuit had simply an air return. The whole of the ampère-turns of exciting power are employed in magnetising the central space, in which, therefore, the actions are very powerful and uniform. The coil and its uses were described in my lecture last year at the Royal Institution on "Optical Torque."

Modifications of the Coil and Plunger.

In one variety of the coil and plunger mechanism, a second coil is wound on the plunger. Hjörth used this modification, and the same thing has been employed in several arc lamps. There is a series of drawings upon this wall, depicting the mechanism of about a dozen different forms of arc lamp, all made by Messrs. Paterson and Cooper. In one of these there is a plunger, with a coil on it, drawn into a tubular coil, the current flowing successively through both coils. In another there are two separate coils in separate circuits, one of thin wire and one of thick, one being connected in series with the arc, and one in shunt.

Differential Coil and Plunger.

There is a third drawing here showing the arrangement, which was originally introduced by Siemens, wherein a plunger is drawn at one end into the coil that is in the main circuit, and at the other end into a coil that is in shunt. That differential arrangement has certain peculiar properties of which I must not now stop to speak in detail. It is obvious that where one core plunges its opposite ends into two coils, the magnetisation will depend on both coils, and the resultant pull will not be simply the difference between the pull of the two coils acting each separately. There is, however, another differential arrangement, used in the Brockie-Pell and other arc lamps, in which there are two separate plungers attached to the two ends of a *see-saw* lever. In this case the two magnetising actions are separate. In a third differential arrangement there is but one plunger and one tubular bobbin, upon which are wound the two coils, differentially, so that the action on the plunger is simply due to the difference between the ampère-turns circulating in the two separate wires.

* Cantor Lecture. Delivered before the Society of Arts, February 3rd, 1890.

Coil and Plunger Coil.

When one abandons iron altogether, and merely uses two tubular coils, one of wide diameter, and another of narrower diameter, capable of entering into the former, and passes electric currents through both of them, if the currents are circulating in the same fashion through both of them they will be drawing into one another. This arrangement has also been used in arc lamps. The parallel currents attract one another inversely, not as the square of the distance, but approximately as the distance. This is one of those little details about which it is as well to be clear. About once a year some kind friend from a distance writes to me pointing out a little slip that he says occurs in my book on electricity, in the passage where I am speaking about the attraction of parallel wires. I have made the terrible blunder of leaving out the word square; for I say the attraction varies inversely as the distance, and my readers are kind enough to correct me. Now when I wrote that passage I considered carefully what I had to write, and the attraction does not vary inversely as the square of the distance, because two parallel wires do not act on one another as two points. They act as two straight lines or two parallel lines, and the attraction between two parallel lines of current, or two parallel lines of magnetism, or two parallel lines of anything else that can attract, will not act inversely as the square, but simply inversely as the distance is between.

Intermediate Forms.

Now this property of the coil and plunger of extending the range of action has been adopted in various ways by inventors whose object was to try and make electro-magnets with a sort of intermediate range. For certain purposes it is desirable to construct an electro-magnet which, while having the powerful pull of the electro-magnet, should have over its limited range of action a more equable pull, resembling in this respect the equalising of range of the coil and plunger. Some of these intermediate forms of apparatus are shown in the following diagrams. Here (fig. 65)

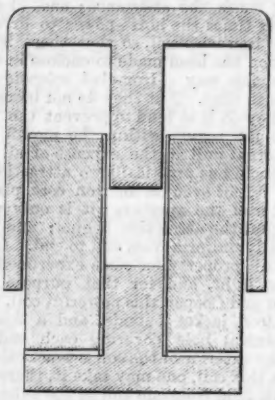


Fig. 65.—Plunger Electro-Magnet of Stevens and Hardy.

is a peculiar form of electro-magnet; it combines some of the features of the iron-clad electro-magnet with those of the movable plunger; it has a limited range of action, but is of great power over that range, owing to its excellent magnetic circuit. It was invented in 1870, by Stevens and Hardy, for use in an electric motor for running sewing machines. A very similar form is used in Weston's arc lamp. A form of plunger electro-magnet, invented by Holroyd Smith in 1877, resembles fig. 65 inverted, the coil being surrounded by an iron jacket, whilst a plunger, furnished at the top with an iron disc, descends down the central tube to meet the iron at the bottom.

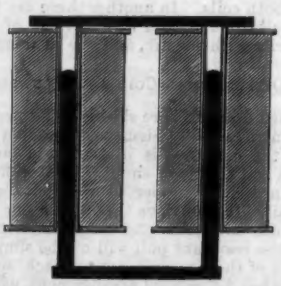


Fig 66.—Electro-Magnet of Brush Arc Lamp.

Then there is another variety, of which I was able to show an example last week by the kindness of the Brush Company, namely, the plunger electro-magnet employed in the Brush arc lamps. A couple of tubular coils receive each an iron plunger, connected together by a yoke; whilst above, the magnetic circuit is partially completed by the sheet of iron which forms part of the enclosing box. You have here, also, the advantage of a fairly complete magnetic circuit, together with a comparatively long travel of the plunger and coil. It is a fair compromise between the two ways of working. The pull is not, however, in any of these forms, equal all along the whole range of travel; it increases as the magnetic circuit becomes more complete.

There are several other intermediate forms. For example, one inventor, Gaiser, employs a horseshoe electro-magnet, the cores of which protrude a good distance beyond the coils, and for an armature he employs a piece of sheet iron, bent round so as to make at its ends two tubes, which enclose the poles, and are drawn down over them. Contrast with this design one of much earlier date by an engineer, Roloff, who made his electro-magnets with iron cores not standing out, but sunk below the level of the ends of the coils, whilst the armature was furnished with little extensions that passed down into these projecting tubular ends of the coils. Some arc lamps have magnets of precisely that form, with a short plunger entering a tubular coil, and met half-way down by a short fixed core inside the tube.

Here (fig. 67) is one form of tubular ironclad electro-magnet that deserves a little more attention, being the one used by Messrs. Ayrton and Perry in 1882; a coil has an iron jacket round it, and also an annular iron disc across the top, and an annular iron disc across the bottom, there being also a short internal tube of iron extending a little way down from the top, almost meeting another

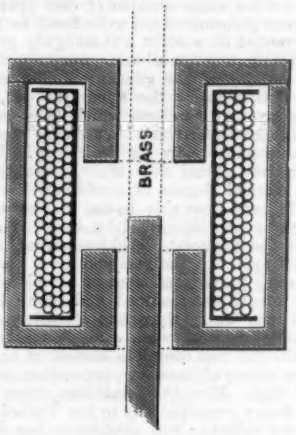


Fig. 67.

Ayrton and Perry's Tubular Ironclad Electro-Magnet.

short internal tube of iron coming up from the bottom. The magnetic effect of the enclosed copper coil is concentrated within an extremely short space, between the ends of the internal tubes, where there is a wonderfully strong uniform field. The range of action you can alter just as you please in the construction by shortening or lengthening the internal tubes. An iron rod inserted below is drawn with great power and equality of pull over the range from one end to the other of these internal tubes.

Action of Magnetic Field on Small Iron Sphere.

In dealing with the action of tubular coils upon iron cores, I showed how, when a very short core is placed in a uniform magnetic field, it is not drawn in either direction. The most extreme case is where a small sphere of soft iron is employed. Such a sphere, if placed in even the most powerful magnetic field, does not tend to move in any direction if the field is truly uniform. If the field is not uniform, then the iron sphere always tends to move from the place where the field is weak to a place where the field is stronger. A ball of bismuth, or one of copper, tends, on the contrary, to move from a place where the field is strong to a place where the field is weaker. This is the explanation of the actions called "dia-magnetic," which were at one time erroneously attributed to a supposed diamagnetic polarity opposite in kind to the ordinary magnetic polarity. A simple way of stating the facts is to say that a small sphere of iron tends to move up the *slope* of a magnetic field, with a force proportional to that slope; whilst (in air) a sphere of bismuth or one of copper tends, with a feeble force, to move down that slope. Any small piece of soft iron—a short cylinder, for example—shows the same kind of behaviour as a small sphere. In some of Ayrton and Perry's coiled-ribbon ampère-meters and voltmeters, and in some of Sir William Thomson's current meters, this principle is applied.

Sectioned Coils, with Plunger.

An important suggestion was made by Page, about 1850, when he designed a form of coil and plunger having a travel of indefinitely long range. The coiled tube, instead of consisting merely of one coil, excited simultaneously throughout its whole length by the current, was constructed in a number of separate sections or short tubes, associated together end to end, and furnished with means for turning on the electric current into any

of the sections separately. Suppose an iron core to be just entering into any section, the current is turned on in that section, and as the end of the core passes through it, the current is then turned on in the section next ahead. In this way an attraction may be kept up along a tube of indefinite length. Page constructed an electric motor on this plan, which was later revived by Du Moncel, and again by Marcel Deprez in his electric "hammer."

Winding of Tubular Coils and Electro-Magnets.

The mention of this mode of winding in sections leads me to say a few final words about winding in general. All ordinary coils, whether tubular or provided with fixed cores, are wound in layers of alternate right-handed and left-handed spirals. In a preceding lecture I mentioned the mistaken notion, now disproved, that there is any gain in making all the spirals right-handed or all left-handed. For one particular case there is an advantage in winding a coil in sections; that is to say, in placing partitions or *cloisons* at intervals along the bobbin, and winding the wire so as to fill up each of the successive spaces between the partitions before passing on from one space to the next. The case in which this construction is advantageous is the unusual case of coils that are to be used with currents supplied at very high potentials. For when currents are supplied at very high potentials there is a very great tension* exerted on the insulating material, tending to pierce it with a spark. By winding a coil in *cloisons*, however, there is never so great a difference of potentials between the windings on two adjacent layers as there would be if the layers were wound from end to end of the whole length of coil. Consequently, there is never so great a tension on the insulating material between the layers, and a coil so wound is less likely to be injured by the occurrence of a spark.

Another variety of winding has been suggested, namely, to employ in the coils a wire of graduated thickness. It has been shown by Sir William Thomson to be advantageous in the construction of the coils of galvanometers to use for the inner coils of small diameter a thin wire; then, as the diameter of the windings increase, a thicker wire; the thickest wire being used on the outermost layers; the gauge being thus proportioned to the diameter of the windings. But it by no means follows that the plan of using *graded wire*, which is satisfactory for galvanometer coils, is necessarily good for electro-magnets. In designing electro-magnets it is necessary to consider the means of getting rid of heat; and it is obvious that the outer layers are those which are in the most favourable position for getting rid of this heat. Experience shows that the under layers of coils of electro-magnets always attain a higher temperature than those at the surface. If, therefore, the inner layers were to be wound with finer wire, offering higher resistance, and generating more heat than the outer layers, this tendency to over-heating would be still more accentuated. Indeed, it would seem wise rather to reverse the galvanometer plan, and wind electro-magnets with wires that are stouter on the inner layers and finer on the outer layers.

Yet another mode of winding is to employ several wires united in parallel, a separate wire being used for each layer, their anterior extremities being all soldered together at one end of the coil, and their posterior extremities being all soldered together at the other. Magnetically, this mode of winding presents not the slightest advantage over winding with a single stout wire of equivalent section. But it has lately been discovered that this mode of winding with *multiple wire* possesses one incidental advantage, namely, that its use diminishes the tendency to sparking which occurs at break of circuit.

Extension of Range by Oblique Approach.

I now pass to the means which have been suggested for extending the range of motion, or of modifying its amount at different parts of the range, so as to equalise the very unequable pull. There are several such devices, some electrical, others purely mechanical, others electro-mechanical. First, there is an electrical method. André proposed that as soon as the armature begun to move nearer, and comes to the place where it is attracted more strongly, it is automatically to make a contact, which will shunt off part of the current and make the magnetism less powerful. Burnett proposed another means; a number of separate electro-magnets acting on one armature, but as the latter approached these electro-magnets were one after the other cut out of the circuit. I need not say the advantages of that method are very hypothetical. Then there is another method which has been used many times with very great success, the method of allowing the motion of the armature to occur obliquely, it being mechanically constrained so as to move past, instead of towards the pole. When the armature is pulled thus obliquely, the pull will be distributed over a definite wider range. Here is a little motor made on that very plan. A number of pieces of iron set on the periphery of a wheel are successively attracted up sideways. An automatic device breaks the circuit as every piece of iron comes near, just at the moment when it gets over the poles, and the current being cut off, it flies on beyond and another piece comes up, is also attracted in the same way, and then allowed to pass. A large number of toy motors have been made from time to time on this plan. I believe Wheatstone was the first to devise the method of oblique approach about the year 1841. He made many little electro-magnetic motors, the armatures of which were in some cases solid rims of iron arranged as a sort of wheel, with two or more zig-zag internal teeth, offering oblique surfaces to the attraction of an electro-magnet. Such little motors are often now used for spinning Geissler's vacuum tubes. In these motors the iron rim is fixed, and the electro-magnet rotates. The pole of the electro-magnet finds itself a certain distance away from the iron ring, it tries to get nearer. The only way it can get nearer is by swinging round, and so it gradually approaches, and as it approaches the place where it is nearest to the internal projection of the rim the current is cut off, and it swings further. This mode may be likened to a cam in a mechanical movement. It is, in fact, nothing else than an *electro-magnetic cam*. There are other devices, too, which are more like electro-magnetic *linkages*. If you curve the poles or shape them out you may obtain actions which are like that of a wedge on an inclined plane. There is an electro-magnet in one of

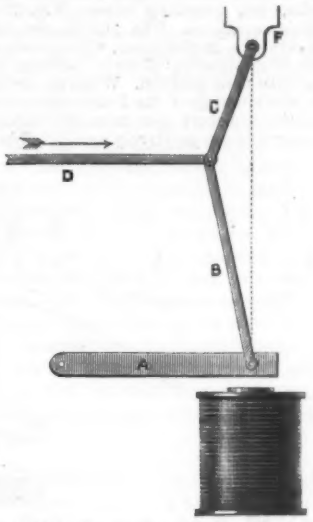


Fig. 68.—Froment's Equaliser with Stanhope Lever.

Paterson and Cooper's arc lamps wherein the pole-piece, coming out below the magnet, has a very peculiar shape, and the armature is so pivoted with respect to the magnet, that as the armature approaches the core as a whole, its surface recedes from that of the pole-piece, the effect being that the pull is equalised over a considerable range of motion. There is a somewhat similar device in De Puydt's pattern of arc lamp.

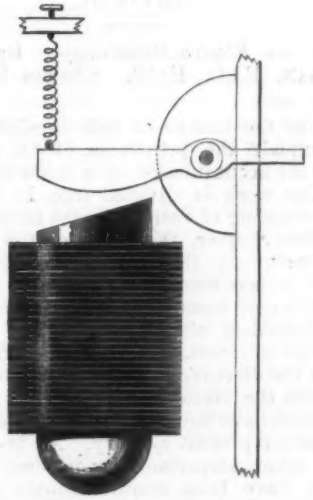


Fig. 69.
Davy's Mode of Controlling Armature by Spring.

Here is another device for oblique approach, made by Froment. In the gap in the circuit of the magnet a sort of iron wedge is put in, which is not attracted squarely to either face, but comes in laterally between guides. Another of Froment's equalisers, or distributors, consists of a parallel motion attachment for the armature, so that oblique approach may take place, without actual

* The tension on the insulating material, tending to pierce it with a spark, is proportional to the square of the difference of potentials (per unit thickness) to which the insulating material is subject. It is incorrect to talk about the tension of the conductor, or about the tension of the current; for the tension or electric stress is always an action affecting the di-electric or insulating material.

contact. Here, fig. 68, is another mechanical method of equalising devised by Froment, and used by Le Roux. You know the Stanhope lever, the object of which is to transform a weak force along a considerable range into a powerful force of short range. Here we use it backwards. The armature itself, which is attracted with a powerful force of short range, is attached to the lower end of the Stanhope lever, and the arm attached to the knee of the lever will deliver a distributed force over quite a different range. One way, not of equalising the actual motion over the range, but of counterbalancing the variable attractive force, is to employ a spring instead of gravity to control the armature. So far back as 1838, Edward Davy, in one of his telegraphic patents, described the use of a spring (fig. 69,) to hold back the armature. Davy preceded Morse in the use of a spring to pull back the armature. There is a way of making a spring act against an armature more stiffly as the pull gets greater. In this method there is a spring with various set screws set up against it, and which come into action at different ranges, so as to alter the stiffness of the spring, making it virtually stiffer as the armature approaches the poles. Yet another method is to employ, as the famous conjuror, Robert Houdin, did, a rocking lever. Fig. 70 depicts one of Robert Houdin's equalisers. The pull of the electro-magnet on the armature acts on a curved lever, which works against a second one; the point of application of force between the one and the other altering with their position. When the armature is far away from the pole, the leverage of the first lever on the second lever is great. When the armature gets near, the leverage of the first lever on the second is comparatively small. This employment of

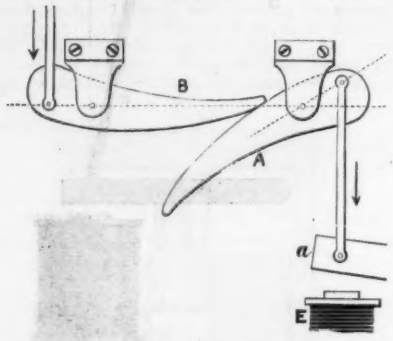


FIG. 70.—ROBERT HOUDIN'S EQUALISER.

the *rocking lever* was adopted from Houdin by Duboscq, and put into the Duboscq arc lamp, where the regulating mechanism at the bottom of the lamp contains a rocking lever.

(To be continued.)

REVIEW.

A Treatise on Electro-Metallurgy. By WALTER G. MCMILLAN, F.I.C., F.C.S. Charles Griffin & Co., London.

The aim of the author of this excellent treatise has been to explain the principles of his subject while avoiding "the accumulation of a mass of unnecessary detail." The work is divided into 18 chapters with addenda consisting of various useful tables.

In the first chapter, the scope of the subject is set down as including electrotyping, electroplating, extraction of metals from their ores, and the dissolving of the surfaces of metals. This is followed by an interesting historical sketch of the few isolated facts known to the ancients, and in the middle ages, up to the date of the discovery of the voltaic battery, which, together with the researches of Faraday and others, is then shown to have led to the remarkable development of the art in the present century. As is the case with so many other important inventions, electrotyping appears to have been simultaneously discovered by several different investigators; Jacobi, of St. Petersburg, and Spencer and Jordan in England.

The second chapter contains the physical and chemical knowledge necessary for understanding the subsequent chapters of the treatise, and though on the whole clear and to the point, we regret to say we have found more blemishes here than in any other part of the work. The author defines matter as that which possesses *weight*; purely *mass* is the essential property of matter; weight is merely a force acting on matter, analogous to electric or magnetic attraction. Also no clear distinction is drawn between force and energy, of which latter, force forms only one factor; at page 22, "chemical *force* is converted into and rendered evident as heat *energy*;" and "it is no more possible to create *force* or *energy*, &c." A little further down on the same page we read: "We are *rarely* able to convert the whole of one kind of energy into any other;" the author should have said—*never*. The definition of a watt at p. 37 requires elucidation and amendment. "A current of 1 ampère at the pressure of 1 volt is termed a *watt*; it is a most useful unit for comparing different currents, and is really the product of volume into pressure;" the product of volume into pressure does not involve the element of time, whereas the *watt* does.

In Chapter III. we have excellent descriptions of batteries, dynamos, and other generators, suitable for electroplating; in some cases a little more detail, we think, might have been given. The author then proceeds to the more technical part of his subject, and here the subject matter is well chosen, and admirably arranged to suit the requirements either of a novice or of a practical electro-metallurgist. Chapter IV. contains general conditions to be observed in electroplating. Chapter V. relates to plating adjuncts and disposition of plant; and Chapter VI. to the cleansing and preparation of work for the depositing vat, and subsequent polishing of plated goods. In Chapter IV. we note a valuable table, showing the average current values suitable for depositing certain metals.

Chapters VII. to XIV. treat of the deposition of various metals and alloys. In each case valuable tables are given of the composition of the baths, giving also the authorities for their use, their special application, and other useful information. At p. 141, an interesting account is given of the experiments of Von Hübl on the effect of varying current strengths on the nature of the copper deposit; and at p. 147, the effect of the burnishing employed in the Elmore process on the tensile strength of the copper. The remaining chapters are devoted to metal extracting and refining processes, electrolytic quantitative analysis, and some other useful matters.

With the exception of the few blemishes which we have noticed above, and which may well be remedied in a second edition, we can commend Mr. McMillan's treatise as one of the best and most complete manuals hitherto published on electro-metallurgy.

NOTES.

Swansea and the Electric Light.—At the last meeting of the electric lighting committee of the Swansea Corporation several reports were presented, amongst them being one from the borough surveyor, and another from Mr. W. H. Preece. The latter gentleman stated that the tender which complied with existing conditions was that of Messrs. Crompton and Company. The system was free from danger, and provided a continuous supply of electric energy of great constancy and steadiness. Speaking of street lighting, he stated that arc lamps, when placed not too far apart, and when they burned with steadiness, invariably gave satisfaction. Glow lamps, unless of considerable power, rarely did so. For street lighting, anything less than 32 C.P. was objectionable, and 50 C.P. was far preferable. The committee decided to accept the tender of Messrs. Crompton to erect twenty-three arc lamps of 2,000 C.P., at a cost of £25 each per annum, the increased charge for which over gas would be £171 per annum.

Electricity and the Census.—Austria is about to follow the example of America, and will use an electrical counter at the next taking of the census.

Electric Lighting of Brussels.—A Belgian daily newspaper states that the municipality of Brussels has definitely resolved not to grant a concession to any company for the electric lighting of that town, but to reserve to itself the right of exploiting the lighting. Thus the propositions which have been made to the municipality on the subject will not be carried into effect. This decision is said to have been arrived at owing to the conditions under which the town could buy up the station, &c., at the termination of the 25 years' concession, being too onerous.

Lighting of Vienna.—The Second Section of the Vienna Municipality has approved of the project between the latter and the International Compressed Air and Electricity Company. According to the scheme, the latter company is empowered to break up the streets to lay down cables and air-pipes, and the concession is given for 45 years. The Municipality can, however, on giving three years' notice, purchase the undertaking at the end of 15, 25, or 35 years.

Electric Lighting at Bournemouth.—At a meeting of the Bournemouth Town Council, last week, a letter was read from the Board of Trade forwarding the report and balance sheet of the Brush Electrical Engineering Company, who are carrying out an extensive installation in the favourite Hampshire watering place. The Town Clerk was instructed to reply that the accounts furnished appeared to show that the company was in a position to discharge the duties imposed by the order. Permission was also given the company to erect certain temporary overhead wires.

The Brighton Council and the Brighton and Hove Electric Lighting Company.—At a meeting of the Brighton Council last week, the General Purposes Committee reported the receipt of notice from the above company of an intended application to the Board of Trade for a Provisional Order, pursuant to the Electric Lighting Acts 1882 and 1888, and that they had instructed the Town Clerk to oppose on behalf of the Corporation, and authorised him to retain Parliamentary agents, counsel, and witnesses for that purpose.

Electric Light in Post Office Work.—It is said that the authorities contemplate installing the electric light in the Bristol general post office. The sorters and other officials, who are obliged to work long hours, complain of the considerable discomfort caused by the heat of the numerous gas jets in the various departments.

Electric Light in Scarborough.—The local authority has decided to apply for a provisional order.

Progress of Civilisation.—The King of the Sandwich Islands, who is at present in New York, is endeavouring to get a telegraphic cable laid between San Francisco and Honolulu.

The Electric Light and Ventilation.—The *Journal of Gas Lighting*, in a lengthy article on "Gas and Electric Lighting and Ventilation," thus concludes:—"There is no need for talking vaguely on this subject; and, in order to bring the question to an issue, we will take a familiar example—the hall of the Society of Arts. This hall is supposed to be ventilated in the so-called 'natural,' as distinguished from the 'mechanical' method, by a sun-light exit shaft, and fresh air admission behind the dado. The sun-light is now replaced by pendants of electric lamps. The question is whether it is better or worse with electric lighting than when gas was solely used. We believe it is much worse; but this is a point the Society ought, in justice to itself, to set right by competent inquiry. Until this is done, and the reputation of the electric lighting is cleared, we shall continue to hold, on *primâ facie* evidence, that the Society's hall is now one of the worst ventilated public rooms in all London, thanks to its electric lamps. And what is true of this hall is probably true, in degree, of many others."

The Pacific Cable.—We reproduce the following paragraph from the Melbourne *Herald* of November 6th:—"Once more Canada has renewed her offer to subsidise liberally any company which shall lay a submarine telegraphic cable between her Pacific coast and Australia. The advantages which would accrue to us from the construction of the line have been again and again described in the *Herald*. It would be quite out of the way of the volcanic disturbances which have so frequently broken our communications by the Eastern route. It would be very easily protected against enemies at sea, and would pass through none but British territory on shore. It would open up communications between Canada and Australia which could not fail to extend our trade, and it would give us a cheaper tariff than we at present pay. It is evident that these are all objects highly important to us. The existing lines pass through territory which may at any moment become hostile, and they are open not only to breakage by submarine eruptions but also to be fished up and broken by an enemy's vessels. In the event of a war we might neutralise the North Pacific line by inducing the United States to take over the guardianship of the cable; but no such course would be open to us with regard to the existing lines, which are quite beyond our control. Ships would presently follow the cable, and a large trade could soon be done with British Columbia. The run from Australia to Vancouver is a quick one, and a quiet one. Our seasons are the direct opposite of those of Canada, and we could sell our wines, our fruits, and many products there, which she requires, just as in return she could help us with many commodities. Assuredly, the entire subject deserves the immediate notice of the Government, who can have no grander task set them than that of drawing together the two great dependencies which between them make up Greater Britain."

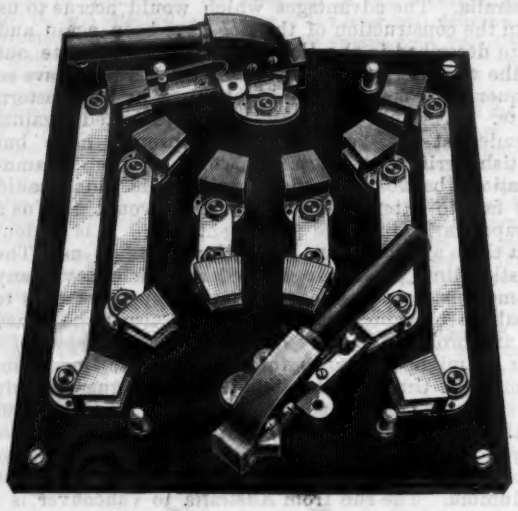
Royal Naval Exhibition.—The electric lighting committee, the members of which are Sir Wm. Thomson, Capt. Eardley Wilmot, R.N., Mr. E. H. Carbutt, Mr. W. H. Preece, and Mr. J. I. Thorneycroft, have decided to entrust the lighting of the entire exhibition to Messrs. Siemens Bros. & Co., who will furnish the dynamos and lamps. The engines will be supplied by Messrs. Willans and Robinson, and the boilers for the electric light, as well as for the machinery in motion, will be from the well-known works of Messrs. Davey, Paxman and Co. At this initial stage, it is premature to say exactly what the extent of the lighting will be; but it is the intention of the committee to make the lighting a brilliant affair in all respects. Some 200 arc lamps and 2,000 glow lamps will probably be required to illuminate the buildings and grounds, and the dynamos will also have to supply current for several interesting applications of the transmission of power, and for the lighthouse of Messrs. Chance Bros., which will form one of the features of the exhibition.

Handy Lists of Technical Literature.—We have received from M. H. E. Haferkorn, of Fourth Avenue, Milwaukee, Wis., Part II.A of his publication, "Handy Lists of Technical Literature." This portion is devoted to books on electricity and magnetism, telegraph, gas, &c., and the compiler believes that this is the first attempt to catalogue the literature on electricity of the period 1880 to October, 1890, in a practical and time-saving way. Everybody interested in this steadily growing branch of study would readily appreciate Mr. Haferkorn's "handy list" as a guide in searching for books on special subjects.

The Henley Companies.—Meetings of Henley's Telegraph Works, Limited, and Henley's Electric Light and Power Company, Limited, were held yesterday at the offices, 27, Martin's Lane, E.C. Press representatives were refused admission.

Electric Light in a Carpet Factory.—The well-known carpet factory of Messrs. Henderson & Co., of Durham, has been fitted with the electric light.

Regulator for Accumulator.—The engraving shows Messrs. Dorman and Smith's patent regulator for use on accumulator circuits. The change in the number of cells being charged or discharged is obtained in such a



manner that the cells are never short-circuited, and the step-by-step motion is instantaneous, even when the handle is moved slowly, this result being obtained in a simple manner, without triggers or complications.

Mechanics' Almanac.—A useful workshop companion is Calvert's Mechanics' Almanac, 1891, being the eighteenth year of its publication. It contains a large amount of information specially interesting to artisans and handicraftsmen, illustrated with diagrams.

A Committee on Electrical Standards.—The President of the Board of Trade has appointed a committee consisting of the following gentlemen, viz. :—

Lord Rayleigh, F.R.S. Sir William Thomson, F R.S.	Representing the Royal Society.
Prof. G. Carey Foster, F.R.S. R. T. Glazebrook, Esq., F.R.S.	Representing the British Association for the Advancement of Science.
Dr. John Hopkinson, F.R.S. Prof. W. E. Ayrton, F.R.S.	Representing the Institution of Electrical Engineers.
E. Graves, Esq. W. H. Preece, Esq., F.R.S.	Representing the General Post Office.
Courtenay Boyle, Esq., C.B. Major P. Cardew, R.E.	Representing the Board of Trade.

to consider whether any and, if so, what steps should be taken for the provision of electrical standards. The first meeting of the committee will be held at the Board of Trade on Thursday, the 15th of January. Sir Thomas Blomefield, of the Board of Trade, will act as Secretary to the committee.

New York Subways.—We extract the following paragraph from a letter which reached us this morning from the States :—"In spite of all the public outcry in New York City, the subways are very little used. The companies interested in electric leads give as an excuse the extravagant rent charged for use of the subways ; the latter are owned or controlled by the "Western Union" and "Bell Telephone," so it is easy for them to have the rent for use fixed to suit themselves.

Share List.—Pressure on our space prevents us publishing the usual share list this week ; but we observe the following changes from last Thursday's prices :—Consolidated Telephones were quoted at from $\frac{1}{2}$ to $\frac{5}{8}$, Elmore's Coppers have gone up and stand at from $4\frac{1}{4}$ to $4\frac{3}{4}$, and Westminster Electric Supplys stand at from $2\frac{1}{2}$ to 3.

The Chelsea Electricity Supply Company and the Vestry.—At the last meeting of the vestry, a letter was read from the Chelsea Electricity Supply Company, giving notice of the intention to discontinue the supply of electricity between the hours of midnight and 4 o'clock in the afternoon, and stating that this was a temporary measure made necessary by the continuance for several days of heavy fogs. Mr. H. J. Wright complained bitterly, as a consumer, of this proposal. He stated that the company had already cut off the supply, and on Saturday morning he was without any light at all. He moved that as the company are applying for a further extension of their order of supply, the Board of Trade should be asked to refuse their assent to such application, unless they would compel the company to give a continuous supply, night and day, even during the foggy weather. After further discussion, in which strong things were said, the motion was carried.

Telephone Management.— Mr. George J. Summerville, who has been manager for the National Telephone Company in the Aberdeen district for the past six years, has been appointed district manager to the Mutual Telephone Company for Lancashire.

The Belgian Society of Electricians.—The Belgian Society of Electricians began, on December 4th, its series of public Thursday lectures, on the premises of the Engineers' Society at the Palais de la Bourse, Brussels. The President, M. Wybauw, in a short opening address, set forth the great change which electricity had imported into the study of all the sciences, and how necessary it was for the engineer, with whichever branch he was connected, to keep himself *au courant* with the researches of which this relatively new science was the object. By starting public lectures given by its members, the Belgian Society of Electricians was endeavouring to meet a real want and to facilitate to all the study, longer or shorter, of electricity and its most frequent applications. The lecturer, Capt. Eugène Lagrange (of the Engineers), a professor at the Military School, afterwards gave, with much clearness, an interesting history of electrical science. This lecture, which was embellished with numerous anecdotes, highly interested those present, and formed a promising beginning for the course. The following ones will be accompanied by experimental demonstrations, which cannot fail to add to their success.

City and South London Railway.—A correspondent has taken the trouble to send us the following figures :—"Trains every five minutes both ways = 168 trains per day of 14 hours. Fare 2d., average 50 passengers = $\frac{365 \times 168 \times 2 \times 50}{240}$ = £25,134, or gross revenue, say, £25,000 per annum. On ordinary railways (steam) the expenses are 50 per cent. of the revenue. If this applies to the above the profit may be, with three million passengers per year and a twopenny fare = £12,500, or $\frac{12,500}{760,000}$ = 1·8 per cent. on capital." Our correspondent has only based his calculations on one line ; he has omitted the return trains, but, on the other hand, his average of 50 passengers on a total train capacity of 100, will be found too high when the company once gets into ordinary everyday work. Perhaps others of our readers may have figured out the probable chances of dividend paying on £760,000 sunk capital ?

Elmore's Foreign and Colonial, &c., Company.—To everybody interested in this concern we recommend the perusal of a letter signed "Vigilans," which appeared in Tuesday's issue of the *Financial Times*.

Another Trans-Continental Wire.—The Western Union has a new wire between San Francisco and New York almost up. It is a Wheatstone automatic circuit, and is intended for California through business exclusively.

Who is Henry Hickman?—We extract the following from the *Financial Times* of Monday:—Would Mr. William Elmore have any objection to tell us precisely who is "Henry Hickman, engineer, 51 and 53, Handforth Road, London, S.W.?" We are curious to know, because Mr. Hickman holds 4,660 shares in MacIvor's Patents, Limited, and because he took the trouble to write to us to assert his perfect confidence in the MacIvor process, citing his large holding as proof of his faith. But when Mr. Henry Hickman is written to at the address he gives in the register of shareholders, and which he gave to us, the Post Office returns the letter marked, "No such number, and name unknown in Handforth Road, Stockwell, S.W." Can Mr. Hickman be produced, and, if he can, why does he not give an address that can be traced? Perhaps Mr. Elmore will explain, as we are not disposed to pay much heed to Mr. Henry Hickman's communications.

Electric Lighting Complaints.—Mr. R. Chamberlain returns to his attack on the Chelsea Electricity Supply Company, and states that during the recent foggy weather, the potential difference at the lamp terminals has been less than 90 volts. Naturally this leaves one's house very badly lighted, and the chairman of the company attempts to show that the recent continuous fogs have drained the reserves of electricity in the accumulators. He omits to say, however, that this excuse is invalid, because the dynamos ought to be able to supply all the maximum current required at any period. It appears to us that the great drop in E.M.F. shows that at the time of maximum demand the leads are too small, and that sudden strains upon the output of the station, such as now exist, had not been allowed for. To the extraordinary notice which the company has thought it advisable to issue, we refer in our leading columns.

Crystal Palace School of Engineering.—The certificates gained by the students of the Crystal Palace School of Practical Engineering during the past term were presented on Saturday afternoon, in the lecture room of the school, by Major F. A. Marindin (Inspector of Railways), who, in the course of his address to the students, specially referred to the large field opening up for engineers in the direction of electricity, "the future of which no one could foretell, and the importance of which it was almost impossible to exaggerate." The results of the examinations showed that the school was advancing in numbers, and, as in past terms, had been distinguished, not more by the ability and energy of the teachers, than by the great earnestness of the students.

A Lost Opportunity.—*Modern Light and Heat* says: "It is astonishing by what narrow margins some people escape making large fortunes. It is reported that Prof. Alexander Graham Bell tried again and again to persuade Senator Don Cameron to buy a one-half interest in his invention for $10,000. Cameron thought Bell a half-witted dreamer, refused to put up a dollar, and finally gave orders that Bell should no longer be admitted to his office. That half-interest to-day would pay a handsome interest of $10,000,000.

Reuter's Telegram Company, Limited.—A meeting was to be held yesterday for the purpose of confirming the resolutions passed at the meeting held on December 6th, and reported in our issue of December 12th.

TRAFFIC RECEIPTS

The Brazilian Submarine Telegraph Company, Limited. The traffic receipts for the week ending December 19th were £6,118.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending December 19th, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited were £4,815.

NEW COMPANIES REGISTERED.

Electric Stores, Limited.—Capital, £15,000 in £1 shares. Objects: To carry on, either as principals or agents, the business of electrical stores, and for the manufacture and sale of electric, telegraphic, surgical, and scientific instruments. Signatories (with 1 share each): A. L. Martyn, L.R.C.P.L., Saltash; J. R. Davies, 29, Stockwell Park, S.W.; J. R. Davis, Greenwood Road, N.E.; H. R. Pope, Streatham; G. Grant Lobbam, 33, Mornington Road, Regent's Park; T. V. Riodan, Cantley House, Clapham Common; R. S. Jennings, Capel Road, Forest Gate. Registered 17th inst., without special articles, by G. D. Freeman, 103A, Paul Street, Finsbury Square. Registered office, 51, Cannon Street.

New Zealand Electrical Syndicate, Limited.—Capital, £30,000 in £10 shares. Objects: To acquire charters, concessions, and other privileges for the production, storage, and distribution of electricity in New Zealand, Victoria, New South Wales, North, South or Western Australia, Tasmania, New Guinea, the Fiji Islands, or elsewhere in Australasia, and to take over and work the central stations erected by the Gülcher (New) Electric Light and Power Company, Limited, in Wellington, New Zealand. Signatories (with 1 share each): *Daniel de Castro, 6, New Square, Lincoln's Inn: Walter Turnbull, Mount Henley, Sydenham Hill; R. Pryor, 79, Gracechurch Street; *M. S. Vanderbyl, 187, Queen's Gate; *H. Grëwing, 14, Austin Friar's; James Alexander, 3, Great Winchester Street; W. Farmer, 48, Aldermanbury. The signatories denoted by an asterisk, and J. Evelyn Williams, are the first directors. Registered 20th inst. by Reyroux, Phillips & Co., 99, Cannon Street.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

Nottingham Electric Light and Power Company, Limited.—The annual return of this company, made up to the 8th inst., was filed on the 18th inst. The nominal capital is £100,000, divided into 9,900 ordinary and 100 founders' shares of £10 each. The shares taken up are 27 founders' and 200 ordinary, but no call has been made, or paid, in respect thereof. Registered office, 22, Low Pavement, Nottingham.

Electric Trust, Limited.—By a resolution passed by this company in general meeting on the 10th inst., the capital of the company has been increased by the addition thereto of £200 divided into 200 shares of £1 each, beyond the registered capital of £60,000.

Woolwich District Electric Light Company, Limited.—The statutory return of this company, made up to the 17th inst., was filed the same day. The nominal capital is £10,000 in £1 shares; 180 shares are taken up, the full amount has been called thereon, the calls paid amounting to £140 and unpaid to £40. Registered office, 39, William Street, Woolwich.

Bishop Stortford Electric Light and Steam Laundry Company, Limited.—The statutory return of this company, made up to the 17th inst., was filed on the same day. The nominal capital is £10,000 in £1 shares; 11 shares have been taken up, and the full amount has been called thereon, but not paid. Registered office, North Street, Bishops Stortford, Herts.

Swan United Electric Light Company, Limited.—The annual return of this company, made up to the 9th inst., was filed on the 17th inst. The nominal capital is £1,000,000 in £5 shares; the shares taken up are 78,949 ordinary, and 19,750 considered fully paid; upon the former the sum of £3 10s. per share has been called, the calls paid amount to £279,851 10s. The sum of £3,530 has been paid upon 1,201 shares forfeited.

RULES AND REGULATIONS OF THE NEW ENGLAND INSURANCE EXCHANGE FOR ELECTRIC LIGHTING.

ADOPTED SEPT. 27TH, 1890, AND SUPERSEDING ALL PREVIOUS RULES.

Revised in Conjunction with Committee from New England Electric Exchange.

GENERAL REQUIREMENTS.

A CERTIFICATE for all new work or changes in old work (Form "C" for arc, Form "F" for incandescent), should be signed by the party installing or controlling any apparatus. The certificate should be filed with the Secretary of the Local Board of Fire Underwriters having jurisdiction, if there be such; otherwise, with the Secretary of the New England Insurance Exchange, Boston.

This certificate is relied upon as a guaranty until the work can be inspected. Permits for the use of the light or power may be granted as soon as the certificate is duly filed.

Blank certificates may be obtained by application to the Secretary of the New England Insurance Exchange, Boston.

All work should be inspected before any of it is concealed, and to this end notice of concealed work must be given this exchange as soon as work is commenced.

The New England Insurance Exchange reserves the right at any time to add to, change, or modify the accompanying rules, and to enforce such modifications, changes, &c., as it shall deem necessary for safety; and it will use all reasonable efforts to promptly notify all electric light companies of any such change.

Any additional loading of wires, either in a building as a whole, or in any department thereof, without previous notification to the exchange, such as is required, shall be deemed a sufficient cause for the suspension of any permit previously granted, until the same shall have been inspected and approved by this exchange.

This exchange reserves the right to disapprove of the use of any wire, switch, cut-out, or any device, or form of material, which it may consider inconsistent with safety from fire risk, even though it may be proposed to instal the same in conformity with these rules.

The following rules will be strictly enforced, and in no case will a certificate of inspection be issued for work which does not fully comply with the rules in all particulars.

RULES FOR WIRING.

Outside Wires.

1. Conducting wires carried over or attached to buildings, must be (*a*) at least 7 feet above the highest point of flat roofs, and (*b*) 1 foot above the ridge of pitch roofs; (*c*) when in proximity to other conductors likely to divert any portion of the current, they must be protected by guard irons or wires, or a proper additional insulation, as the case may require.

2. For entering buildings, (*a*) wires with an extra heavy water-proof insulation must be used, (*b*) they must be protected by drip loops, (*c*) also protected from abrasion by awning frames (*d*) be at least 6 inches apart, (*e*) the holes through which they pass in the outer wall of such building must be bushed with a non-inflammable, waterproof, insulating tube, and (*f*) should slant towards the inside.

3. The inspector may, at his discretion, require wires, other than those used for conveying current for electric light or power, entering buildings to be protected by some approved automatic cut-out, in any locality where such wires are, in his opinion, liable to come in contact with electric light or power wires.

4. Converters, and the primary wires leading thereto, (*a*) must not be placed inside of any building (central stations excepted); (*b*) they may be attached to the walls on the outside if securely supported by substantial wooden cross pieces or cleats.

5. Wires attached to buildings should be (*a*) free of contact with the building, and (*b*) supported by rubber hooks, glass insulators, or porcelain knobs. (Porcelain knobs should be used to support high potential wires.)

Inside Wires.

[High Potential (over 350 volts) Arc and Series Incandescent.]

6. Wires must enter and leave the building (*a*) at the same place (*b*) through an approved cut-out switch, which must be (*c*) mounted on a non-combustible base if attached to any combustible substance (*d*) kept free from moisture, and (*e*) easy of access to firemen and police.

7. The cut-out switch must be (*a*) double-contact (*b*) must effectually close the main circuit and cut off the interior, when turned "off" (*c*) so constructed that there shall be no arc between the points when thrown "on" or "off" (*d*) automatic in its action (not stopping between points when once started) (*e*) and indicate upon inspection whether the current be "on" or "off."

8. Wires (*a*) must be rigidly supported (*b*) on porcelain, glass, or other non-combustible insulators (*c*) free from contact with the building, (*d*) have water-proof insulation wherever there is a possible exposure to moisture, (*e*) be at least 12 inches apart, and (*f*) at least 3 inches from any other substance capable of acting as a conductor.

9. (*a*) When wires pass through walls, floors, partitions, &c., (*b*) or wherever protection from mechanical injury is necessary, (*c*) they must be protected by glass, hard rubber, or other moisture-proof, non-inflammable tubing. (*d*) Soft rubber tubing will not be approved.

10. (*a*) No concealed work (*b*) or wires fastened with metallic staples will be approved.

11. In perfectly dry places wires (*a*) supported by wooden cleats, which (*b*) are "filled" to prevent the absorption of moisture, and (*c*) have a backing so as to separate the wire at least one-fourth inch from the building, may be approved by the inspector.

12. A wire (*a*) having a non-inflammable insulation, and (*b*) be enclosed in a moisture-proof (*c*) insulating conduit or tubing (*d*) sufficiently strong to protect the wire from mechanical injury, may be used, in which case the tube may be fastened by metallic loops if desired, and the distance between wires reduced to 3 inches; but (*e*) the entire "conduit system" must be moisture-tight—i.e., joints and open ends must be sealed with some approved cement.

13. The "series" incandescent lamp must (*a*) be provided with a proper hand-switch, and (*b*) an approved automatic device which will shunt the circuit around the carbon filament should it break; (*c*) it must be suspended from a hanger board by means of a rigid tube, and (*d*) must not be used in damp or wet places.

14. Any method of distributing current to incandescent lamps on high potential circuits other than as above provided for, must receive the approval of this exchange before being put into use.

15. In arc lamps indoors, (*a*) the light must be surrounded by a globe with a closed base; (*b*) the depth of the globe must be such that the point of contact between the carbons, when the lamp is newly trimmed, shall not be less than 3 inches below the upper edge of the globe; and (*c*) the globe must be enclosed by a wire netting where there is any material under the lamp that could be damaged or ignited by hot cinders, or (*d*) when the lamp is an "all night" lamp. (*e*) Where exposed to flyings, or where any inflammable material is suspended near the lamp, spark arresters must be used.

16. Hanger boards for arc or series incandescent lamps must not be used in damp places or wet places.

17. Each arc lamp must be provided (*a*) with a proper hand switch, (*b*) with an automatic switch that will shunt the current around the carbons should they fail to feed properly, and (*c*) with "stops" to prevent the carbons from falling out in case their clamps fail to hold them.

18. The entire installation must test free from grounds.

[Low potential (350 volts or less) incandescent.]

19. For inside work, no wire smaller than No. 14 "B. and S," or No. 16 "B.W.G.," will be approved.

20. Samples of wire to be used, or in actual use, must be submitted to this exchange, for tests of conductivity or of insulation, at any time when required.

21. (*a*) Wires must never be left exposed to mechanical injury, or to disturbance of any kind. (*b*) Wires must not be fastened by metallic staples. (*c*) When wires pass through walls, floors, partitions, timbers, &c., glass tubing, or so-called "floor insulators," or other moisture-proof, non-inflammable, insulating tubing must be used. (*d*) At all outlets to and from cut-outs, switches, fixtures, &c., wires must be separated from gas pipes or parts of the building by porcelain, glass, or other non-inflammable insulating tubing, (*e*) and should be left in such a way as not to be disturbed by the plasterers. (*f*) Wires of whatever insulation must not in any case be taped or otherwise fastened to gas piping. (*g*) If no gas pipes are installed at the outlets, an approved substantial support must be provided for the fixtures.

22. In crossing any metal pipes, or any other conductor, (*a*) wires must be separated from the same by an air space of at least ½ inch, where possible, and (*b*) so arranged that they cannot come in contact with each other by accident. (*c*) They should go *over* water pipes.

23. Twin wires must not be used except (*a*) as allowed in "conduit" wiring, (*b*) or for "pendants," fixture wiring, and "portables." (*c*) An exception may be made to this rule, by the inspector, where it is necessary to run a short distance, if the wire (*d*) has a non-inflammable covering, (*e*) is not concealed, and (*f*) carries but a small current.

24. The safe carrying capacity of wires when exposed to the air may be taken from the following table:—

B. and S. gauge.	Current in amperes.
0000	300
000	245
00	215
0	190
1	160
2	135
3	115
4	100
5	90
6	80
7	67
8	60
10	40
12	30
14	22
16	15

When wires are enclosed in moulding or otherwise treated so as to prevent cooling by radiation, the carrying capacity is reduced

about 40 per cent., and under such circumstances, or when the wires are installed where the temperature is unusually high, as in boiler rooms, and the like, wires should be fused accordingly.

25. (*a*) In rooms where inflammable gases may develop, or (*b*) where the atmosphere is very damp, the incandescent lamps should be enclosed in vapour-tight globes. (*c*) Switches are not permitted in places filled with inflammable gases, breweries, distilleries, &c., as the spark at make or break might cause explosion. (*d*) Fusible safety plugs, if necessary in such places, must be enclosed in air-tight, non-combustible cases.

26. Soft rubber tubing will not be approved in cases where these rules require an additional covering to the insulation of the wire.

27. The entire installation must test free from grounds.

WIRING.

Cleat Work.

28. (*a*) Cleats made of well-filled, dry, hard wood may be used to support wires not concealed, in perfectly dry places only. (*b*) They must be so constructed as to separate wires of opposite polarity at least 2½ inches. (*c*) Wires must be drawn taut, and cleats placed near enough together to prevent the possibility of contact between the wires.

29. Except on wooden surfaces so filled as to prevent the absorption of moisture (*a*) the wire must have a waterproof insulation, or (*b*) the cleats must have a backing that will separate the wire at least ¼ inch from the building.

Moulding.

30. Mouldings must not be used (*a*) in concealed work, nor (*b*) in places where there is any probable exposure to moisture.

31. (*a*) Moulding must consist of two parts: viz., a back-piece, which shall separate the wire at least one-fourth inch from the part of the building to which it is fastened, and a cover, one of which parts shall contain the grooves, (*b*) these grooves to have between them a septum or tongue of wood so as to separate the wires at least one-half inch. (*c*) The moulding must be coated inside and out with shellac or water-proof paint, or treated in some other manner so as to prevent any possible absorption of moisture. (*d*) Mouldings with open grooves laid against walls or ceilings will only be approved when such walls or ceilings are of wood, and so filled as to prevent the absorption of moisture.

Concealed Work.

32. In unfinished lofts, between floors and ceilings, in partitions, and other concealed places, wires must (*a*) be kept free of contact with the building, (*b*) be supported on glass, porcelain, or other non-combustible insulators, (*c*) have at least one inch clear air space surrounding them, (*d*) be at least 10 inches apart when possible, and (*e*) should be run singly on separate timbers or studding. (*f*) When thus run in perfectly dry places, and liable to be exposed to moisture, a wire having simply a non-combustible insulation may be used.

33. Wires run as above (*a*) immediately under roofs (*b*) in proximity to water tanks. or pipes, will be considered as exposed to moisture; and in such places the insulating covering of the wire must consist of a water-proof covering next the wire, protected by an external covering not easily abraided, and that will not support combustion.

34. Wires must not be fished (*a*) for any great distance, and (*b*) only in places where the inspector can satisfy himself that the above rules have been complied with. (*c*) Twin wires must never be employed in this class of concealed work.

Conduit Wiring.

35. Wires may also be concealed by means of a system of insulating tubes, or "conduits," that are moisture-proof and practically non-inflammable, and have a threaded joint. (*a*) A separate tube must be provided for each wire, except (*b*) in case of taps or branches carrying a current that does not exceed 15 ampères, in which case a flexible twin cable may be used; but (*c*) the two conductors of this cable must not be insulated from each other by a rubber compound. A cotton or other fibrous covering should be used, and (*d*) the joints between sections must be made moisture proof, with some cement proper for the purpose; i.e., the whole system must be free from joints, cracks, &c., where it would be possible for moisture to enter the tubing.

36. These tubes may be secured by metallic loops, and may be laid side by side.

37. This is the only manner in which wires may be run imbedded in plaster, cement, or any similar material. Wires run on brick walls or below timbers furred for lath and plaster will be considered as imbedded in plaster, unless the furring strips are of such thickness as to prevent any contact between the wire and the clinches of plaster.

Wires in Damp Places.

38. In dye houses, paper and pulp mills, and other buildings especially liable to moisture, all wires, except those used for pendants, must (*a*) be separated at least 6 inches, (*b*) be thoroughly and carefully put up, and (*c*) be supported by glass or porcelain insulators, or by rubber hooks.

39. Where it is necessary to run the wires down a side wall in order to pass through a floor, the wires must (*a*) be supported from the ceiling to the floor on insulators, (*b*) placed, if necessary, on a back board, and (*c*) to protect the wires from injury, they should be boxed over from the floor to a point 5 or 6 feet above.

40. Where exposed to acid fumes, vapors of ammonia, &c., wires should (*a*) be provided with an insulation, and (*b*) supported on insulators that will not be injured thereby.

In places covered by Rules 38 and 40, wires may be run under rules for "conduit" wiring, and if to be concealed they must be so run, but in either case will be subject to special approval by the inspector.

FITTINGS AND APPARATUS.

Safety Cut-outs.

42. (*a*) Every portion of each installation must be equipped with safety cut-outs, that will interrupt the passage of a current in excess of the amount which that portion of the apparatus is adequate to transmit. (*b*) Fusible leads designed to carry a current of 10 ampères or over must have contact surfaces of some harder material. (*c*) Fusible leads should be proportioned to the capacity of the wire they are to protect, and not to the number of ampères required to supply the lamps on that particular circuit. (*d*) A cut-out must be placed where the underground or overhead service joins the inside wires, and (*e*) at every point where a change is made in the size of the wire (unless the cut-out in the larger wire is intended to protect the smaller). (*f*) A cut-out must be provided for each fixture, and (*g*) in concealed wiring, for each pendant also; but (*h*) where the wires are exposed, one cut-out may be employed to protect two or more pendants, provided (*i*) the amount of current they require does not exceed 7 ampères. (*j*) Stiff brackets not attached to gas pipes may be treated as pendants in this connection.

43. All cut-out devices must (*a*) be made of non-combustible material, and (*b*) be placed so as to protect both sides of the circuit, and (*c*) be provided with close-fitting covers.

44. When lights are grouped, as upon electroliers, &c., the small wires to each light cannot always have cut-outs. Care should be taken, however, that the least controlling cut-out (*a*) carries as small an amount of current as practicable, and (*b*) that it will act before the smallest wire runs any risk of being unduly heated.

Switches.

45. All switches must (*a*) be composed entirely of non-combustible material, and (*b*) be automatic in action.

46. All switches must be double-pole, in circuits (*a*) connected to fixtures attached to gas pipes, or (*b*) carrying a current of 10 ampères or over.

Pendants, Portables, &c.

47. (*a*) Lamps may be suspended by flexible cord pendants not less than No. 16 B. and S. or No. 18 B.W.G. (*b*) Where it enters the lamp socket, the cord must be protected by a bushing of rubber, wood, or some similar insulating material, and (*c*) the cord must be so arranged that the weight of the lamp, &c., shall not be borne by the joints or binding screws.

48. (*a*) The covering of the flexible cord, as a whole, shall be of such a nature that it will not support combustion, (*b*) in damp places the cord must have a moisture-proof covering, and (*c*) the openings at the top of the socket must be closed, so as to prevent the entrance of water. (*d*) The flexible leads of the portable fittings must in all cases be protected by cut-outs at their fixed points of connection.

Fixtures.

49. (*a*) Each fixture to which wires are attached must be insulated from the piping of the building by an insulating joint. (*b*) Burrs and sharp edges must be removed before wires are drawn into a fixture. (*c*) Wires attached to, or concealed within fixtures, must have an insulating covering that cannot be easily cut or abraded, and (d) that is moisture proof; (*e*) where attached to the outside of a gas fixture, the conductors must be so secured that their covering will not be cut or abraded by the swaying of the fixture or the movement of the bracket arm. (*f*) The difference of potential between any two wires connected with a combination or gas fixture, must not exceed 125 volts. (*g*) No wire smaller than No. 16 B and S. or No. 18 B.W.G. must be used in fixture wiring.

Electric Gas Lighting.

50. Where electric gas lighting is to be used on the same fixture with the electric light (*a*) no part of the gas piping or fixture shall be in connection with the gas lighting circuit; (*b*) the wires used for the fixture must have a non-inflammable insulation, or (*c*) if concealed between the pipes, and a shell of the fixture, must have an insulation such as is required for fixture wiring for the electric light; (*d*) the whole installation must test free of grounds, and (*e*) the two installations must test perfectly free of connection with each other. (*f*) Any such installation will then be subject to special approval by the inspector.

Arc Lights on Low Potential Circuits.

51. This system of lighting will in general be governed by the foregoing rules for low potential work, but (*a*) no wire smaller than No. 12 B. and S. must be used; (*b*) there must be a double pole cut-out at the junction of the branch with the main, and (*c*) a double pole switch in the branch. (*d*) The cut-out, switch, and resistance device must be composed of non-inflammable material. (*e*) The light must be protected by a globe, &c., the same as is required for a high potential lamp.

ISOLATED PLANTS.

52. In isolated plants, (*a*) the dynamo, regulating devices, switchboards, and all wires connecting the same, must be installed in conformity with the requirements for a standard central station (see 53 to 67), and (*b*) should never be placed in any room where they will be exposed to flyings of any combustible materials.

Dynamos.

53. (*a*) Insulated on thoroughly dry wood, (*b*) "filled" to prevent absorption of moisture. (*c*) A waterproof cover should be provided, and kept over each dynamo when not running.

Wires.

54. (*a*) Wires from dynamos to switchboard, and (*b*) thence to outside lines ('bus wires, feeders, primary mains, arc circuit leads and returns) (*c*) to be wholly exposed to view (*d*) supported by glass or porcelain insulators, and (*e*) of sufficient sectional area to prevent heating. (*f*) Where passing through floors, partitions, or other woodwork, (*g*) to be protected by substantial tubes of glass or porcelain, (*h*) which shall project above and below floors, and beyond the surface of partitions, so as to insure perfect insulation. (*i*) Hard rubber tubing may be used, except where passing through the floors at or near the dynamo.

55. (*a*) Where leaving the building, the wires to be looped downward, and (*b*) the tubes in which they are enclosed to be inclined so as to prevent the entrance of rain water along the wires.

56. (*a*) Wires of opposite polarity should be separated at least 12 inches, (*b*) particularly where passing through floors and partitions. (*c*) Conductors from ceiling or floor to switchboard may be run at less distance than 12 inches from each other, (*d*) but in that case an approved insulation must be provided.

57. If (*a*) conductors from dynamos are run under floors, (*b*) except the space underneath be a perfectly dry finished room, and (*c*) not less than 6 feet between floors, (*d*) they must be specially insulated and will then be subject to approval.

58. (*a*) Each feeder and primary main to be provided with a safety fuse on a non-combustible base. (*b*) All wire connections must be soldered, if necessary, to secure good contact.

59. Branch wires for station lighting to be in accordance with the requirements of this exchange for electric light wiring.

Switchboards.

60. (*a*) To be kept free from moisture (*b*) located apart from wood work (*c*) accessible from all sides (*d*) not enclosed, and (*e*) with all electrical devices, wires and connections in plain sight. (*f*) When all wires and electrical devices are on the front, the switchboard may be set against a brick wall (*g*) but must be detached from any wood work. (*h*) The switchboard should be constructed either of slate or some other non-combustible insulating substance, or (*i*) so-called "skeleton."

61. (*a*) All switches and wires on the switchboard must have ample capacity and (*b*) contact to carry their possible maximum load without heating.

Lightning Arresters.

62. (*a*) To be located in sight of attendants, and (*b*) so placed and constructed that an arc if formed will not come in contact with wood work or other combustible material. (*c*) Lightning arresters should be so designed as to automatically destroy any arc which may be formed by a lightning discharge or otherwise.

Equalisers.

63. (*a*) Frames to be constructed of non-combustible material. (*b*) To be open and accessible from all sides (*c*) supported at least 12 inches from all wood work (*d*) and located so as to be in sight of dynamo attendant.

64. (*a*) All resistance devices to be so designed as to heat but slightly when in use, and (*b*) connected so as not to be liable from a short circuit or other cause to an over charge of current; (*c*) otherwise they must be enclosed in non-combustible cases and (*d*) kept away from any woodwork.

Care and Attendance.

65. A competent man must be kept constantly in the dynamo room while the dynamos are running.

66. (*a*) Oil must not be allowed to accumulate on the floor, and (*b*) all oily waste must be kept in standard metal waste cans, or (*c*) removed from the station daily after the dynamos are stopped and cleaned.

67. Arc lamps must always be provided with perfect globes.

MOTORS.

68. Motors must (*a*) be placed as near as possible to the point where wires enter the building (*b*) be mounted on filled, dry wood, (*c*) be raised at least 8 inches above the surrounding floor, (*d*) be kept clean, and (*e*) covered with a waterproof cover when not in use, and (*f*) if deemed necessary by the inspector, be enclosed in an approved case.

69. Standard metal waste cans, with a self-closing cover and legs raising the can at least 3 inches from the floor, must be provided for oily waste.

Switches, Regulators, and Cut-outs.

70. (*a*) The controlling switch must be so constructed as to entirely disconnect the motor from the circuit, and (*b*) a cut-out such as is required for a similar lighting circuit must be placed as near as possible to the point where the wires enter the building.

71. All switches, regulators, cut-outs, &c., must (*a*) be as nearly non-combustible as possible, (*b*) be protected from moisture, (*c*) have a backing of porcelain, slate, cement, asbestos, or other equally non-combustible substance, and (*d*) be perfectly insulated.

Wiring.

72. (*a*) Wire having a waterproof insulation must be used. (*b*) The wire must be rigidly supported (*c*) on porcelain, glass or other non-combustible insulators, free from contact with the building, and (*d*) at least 6 inches apart. (*e*) No concealed work, (*f*) cleat work, or (*g*) wires fastened with metallic staples, will be approved.

73. (*a*) when wires pass through walls, floors, partitions, &c., or (*b*) wherever protection from mechanical injury is necessary, (*c*) they must be protected by glass, hard rubber, or other moisture proof, non-inflammable tubing. (*d*) (Soft rubber tubing will not be approved.)

74. These rules are not intended to preclude the running of small motors (for fans and the like) on low potential lighting circuits, the installation of which has received the approval of the inspector.

75. The entire installation must test free from grounds; but motors run on a "ground circuit" may be approved by the inspector, under these rules, provided the return wire is carried to a ground outside of the building.

LIGHTING FROM GROUND RETURN POWER CIRCUITS.

76. Electric railway power stations and their car sheds may be lighted by incandescent lamps connected with their power wires, if the installation of the wires meets with the approval of the inspector, but no other property may be so lighted.

MISCELLANEOUS.

77. Splices in both arc and incandescent circuit wires must be made so that a perfectly secure and unvarying connection, fully equal to the cross section of the wire will be secured. The splice must be soldered, but solder must never be employed to complete a joint that would be loose or insecure without it. Either resin or an acid solution may be used as a flux; both are objectionable if not carefully applied.

78. Architects are urged to familiarise themselves with these rules, and to see that all contracts are made subject to the work being done in accordance therewith, and also to see that it has so done. The New England Insurance Exchange will gladly aid them to this end by giving information, advice, or inspection to as great an extent as possible.

79. A great danger in all installations is from poor contacts; consequently, avoid screw joints as much as possible; screw them up tight, with good areas of contact; on no account allow them out of sight. Solder ever connection as far as practicable.

80. When an electrical fire breaks out, turn off the current at the nearest switch, or sever the conductors (one at a time); then use your appliances. The injudicious use of water without these precautions may only increase the extent of the fire. In severing the conductors of high electromotive force, be careful that you stand on a good insulator, such as dry wood, and that the handle of your hatchet is dry, or personal injury may result.

PROCEEDINGS OF SOCIETIES.

Physical Society.—December 12th, 1890.

Prof. W. E. AYRTON, President, in the Chair.

Mr. SHELFORD BIDWELL, F.R.S., showed "Some Experiments with Selenium Cells." The crystalline variety of selenium was, he said, most interesting to physicists owing to its electrical resistance being greatly diminished by light. This property was shown experimentally with different forms of cells, the construction of which were explained. The form recommended was that in which two copper wires are wound near each other round a slip of mica, and the spaces between the wires filled with selenium. The wires form the terminals of the so-called "cell," which, before being used, is annealed for several hours at a temperature above 200° C. Many such cells were made in 1880, 1881, and their sensitiveness to light remained unimpaired during 1882. In 1885, however, several were found less sensitive, and others totally useless; only one out of thirteen retained its sensibility till September, 1890. The loss of sensitiveness Mr. Bidwell believes due to an excessive amount of selenide of copper being formed, for although some selenide is essential to the satisfactory working of the cell, too much is fatal to its action. The selenide of one defective cell was electrolysed, red tufts of amorphous selenium appearing on the anodes. A white substance resembling moist calcium chloride was also present; this he believed to be oxide or hydroxide of selenium. Small polarisation currents had been obtained from selenium cells.

A lecture apparatus illustrating the properties of selenium cells was exhibited. It consisted of a cell connected in series with a relay and a battery. The relay was arranged so that it might

either ring a bell or light an incandescent lamp. When the bell was joined up, it remained silent so long as the selenium cell was illuminated, but on screening the cell, the bell rang. By using various coloured glasses as screens, the effect was shown to be due to the red and yellow rays. A similar experiment with the glow lamp was very striking, for, on turning down the gas lamp illuminating the cell, the electric lamp lighted, and was extinguished on turning up the gas. This demonstrated the possibility of an automatic lamp-lighter which would light or put out lamps according as they are required or superfluous. Amongst the other practical applications suggested were, announcing the accidental extinction of railway signal lamps or ships' lights, and the protection of safes and strong rooms.

Prof. MINCHIN said he had lately constructed cells of a different kind to those shown by Mr. Bidwell, and found that they gave an E.M.F. when exposed to light. For his purposes the long annealing, &c., were quite unnecessary, and a complete cell could be made in 10 minutes. One of his cells gave an E.M.F. of over 1 volt as measured by an electrometer, by the light of a fog. Their promptness of action falls off in a day or two, but if they are kept on open circuit, a week has no effect on the final E.M.F. On closed circuit, however, they deteriorate.

Prof. S. U. PICKERING said both oxides of selenium were deliquescent, and the author's conclusion as to the white substance formed by electrolysis was probably correct.

Prof. S. P. THOMPSON believed Prof. Graham Bell had tried platinum instead of copper, and found that the selenium cracked off in annealing. He also found that it was only necessary to carry on the annealing until the characteristic slate colour appeared. Mr. Bidwell's experiments, he said, showed the possibility of seeing at a distance, and had also suggested to him that the effect of screening might be utilised for driving a completely detached pendulum electrically.

Prof. FORBES said that silver sulphide, when electrolysed, presented appearances resembling those noticed by Mr. Bidwell in copper selenide.

In reply to questions from the PRESIDENT and Prof. PERRY as to whether the low resistance and unsensitiveness of old cells was due to moisture, Mr. BIDWELL said drying them had no effect, but baking restored the resistance, but not their sensitiveness. Speaking of the effect of annealing cells, he said this reduced their resistance considerably. Prof. Graham Bell, he believed, gave up using platinum because the resistances of such cells were very high.

Mr. JAMES SWINBURNE read a paper on "Alternate Current Condensers." It is, he said, generally assumed that there is no difficulty in making commercial condensers for high pressure alternating currents. The first difficulty is insulation, for the dielectric must be very thin, else the volume of the condenser is too great. Some dielectrics, 0·2 mm. thick, can be made to stand up to 8,000 volts when in small pieces, but in complete condensers a much greater margin must be allowed. Another difficulty arises from absorption, and whenever this occurs, the apparent capacity is greater than the calculated. Supposing the fibres of paper in a paper condenser to be conductors embedded in insulating hydrocarbon, then every time the condensers is charged, the fibres have their ends at different potentials, so a current passes to equalise them, and energy is lost. This current increases the capacity. One condenser made of paper boiled in ozokerite took an abnormally large current, and heated rapidly. At a high temperature it gave off water, and the power wasted and current taken, gradually decreased. When a thin plate of mica is put between tin foils, it heats successively, and the fall of potential over the air films separating the mica and foil is great enough to cause disruptive discharge to the surface of the mica. There appears to be a luminous layer of minute sparks under the foils, and there is a strong smell of ozone. In a dielectric which heats, there may be three kinds of conduction, viz., metallic, when an ordinary conductor is imbedded in an insulator; disruptive, as probably occurs in the case of mica; and electrolytic, which might occur in glass. In a transparent dielectric, the conduction must be either electrolytic or disruptive; otherwise light vibrations would be damped. The dielectric loss in a cable may be serious. Calculating from the waste in a condenser made of paper soaked in hot ozokerite, the loss in one of the Deptford mains came out 7,000 watts. Another effect observed at Deptford is a rise of pressure in the mains. There is, as yet, no authoritive relative statement as to exactly what happens, and it is generally assumed that the effect depends on the relation of capacity to self-induction, and is a sort of resonator action. This would need a large self-induction, and a small change of speed would stop the effect. The following explanation is suggested. When a condenser is put on a dynamo the condenser current leads relatively to the electromotive force, and therefore strengthens the field magnets, and increases the pressure. In order to test this the following experiment was made for the author by Mr. W. F. Bourne. A gramme alternator was coupled to the low pressure coil of a transformer, and a hot-wire voltmeter put across the primary circuit. On putting a condenser on the high pressure circuit the voltmeter wire fused. The possibility of making an alternate excite itself, like a series machine, by putting a condenser on it, is pointed out.

Professor PERRY said it would seem possible to obtain energy from an alternator without exciting the magnets independently, the field being altogether due to the armature currents.

Mr. SWINBURNE remarked that this could be done by making the rotating magnets a star-shaped mass of iron.

Sir W. THOMSON thought Mr. Swinburne's estimate of the loss in the Deptford mains was rather high. He himself had calculated the power spent in charging them, and found it to be about 16 horse power; and although a considerable fraction might be lost, it would not amount to nine-sixteenths. He was surprised to hear that glass condensers heated, and inquired whether this heating was due to flashes passing between the foil and the glass.

Mr. A. P. TROTTER said Mr. Ferranti informed him that the capacity of his mains was about one-third microfarad per mile, thus making 2⅓rd microfarads for the seven miles. The heaping up of the potential only took place when transformers were used, and not when the dynamos were connected direct. In the former case the increase of volts was proportional to the length of main used, and 8,500 at Deptford gave 10,000 at London.

Mr. BLAKESLEY described a simple method of determining the loss of power in a condenser by the use of three electro-dynamometers, one of which has its coils separate. Of these coils, one is put in the condenser circuit, and the other in series with a non-inductive resistance r, shunting the condenser. If a_2 be the reading of a dynamometer in the shunt circuit and a_3, that of the divided dynamometer, the power lost is given by $r\ (ca_3 - b\ a_2)$, where B and C are the constants of the instruments on which a_2 and a_3 are the respective readings.

Prof. S. P. THOMPSON asked if Mr. Swinburne had found any dielectric which had no absorption. So far as he was aware, pure quartz crystal was the only substance.

Prof. FORBES said Dr. Hopkinson had found a glass which showed none.

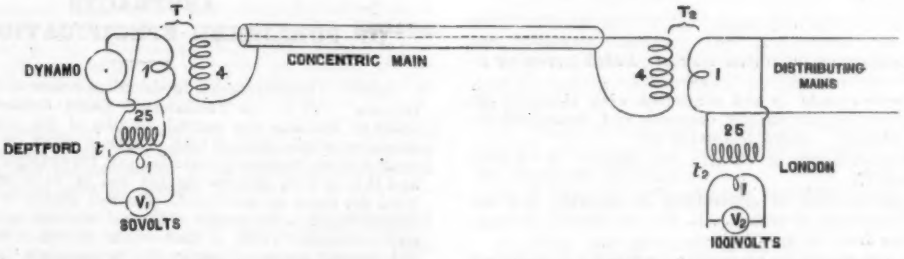
Sir W. THOMSON, referring to the same subject, said that many years ago he made some tests on glass bottles, which showed no appreciable absorption. Sulphuric acid was used for the coatings, and he found them to be completely discharged by an instantaneous contact of two balls. The duration of contact would, according to some remarkable mathematical work done by Hertz in 1882, be about 0·0004 second, and even this short time sufficed to discharge them completely. On the other hand, Leyden jars with tinfoil coatings showed considerable absorption, and this he thought due to want of close contact between the foil and the glass. To test this, he suggested that mercury coatings be tried.

Mr. KAPP considered the loss of power in condensers due to two causes; first, that due to the charge soaking in, and second, to imperfect elasticity of the dielectric. Speaking of the extraordinary rise of pressure on the Deptford mains, he said he had observed similar effects with other cables. In his experiments, the sparking distance of a 14,000-volt transformer was increased from $\frac{1}{12}$th of an inch to one inch by connecting the cables to its terminals. No difference was detected between the sparking distances at the two ends of the cable, nor was any rise of pressure observed when the cables were joined direct on the dynamo. In his opinion, the rise was due to some kind of resonance, and would be a maximum for some particular frequency.

Mr. MORDEY mentioned a peculiar phenomenon observed in the manufacture of his alternators. Each coil was tested to double the pressure of the complete dynamo, but when they were all fitted together, their insulation broke down at the same volts. The difficulty had been overcome by making the separate coils to stand much higher pressures.

Prof. RÜCKER called attention to the fact that dielectrics alter in volume under electric stress, and said that if the material was imperfectly elastic some loss would result.

The PRESIDENT said that as some doubt existed as to what Mr. Ferranti had actually observed, he would illustrate the arrangements by a diagram:—



Explanation of Diagram:—T_1 and T_2 are large transformers; t_1 and t_2 are small transformers for voltmeters, V_1 and V_2. The numbers 1, 4, 1, 25, represent their conversion ratios.

Speaking of condensers, he said he had recently tried lead plates in water to get large capacities, but, so far, had not been successful.

Mr. SWINBURNE, in replying, said he had not made a perfect condenser yet, for although he had some which did not heat much, they made a great noise. He did not see how the rise of pressure observed by Mr. Ferranti and Mr. Kapp could be due to resonance. Mr. Kapp's experiment was not conclusive, for the length of spark is not an accurate measure of electromotive force. As regards Mr Mordey's observation, he thought the action explicable on the theory of the leading condenser current acting on the field magnets. The same explanation is also applicable to the Deptford case, for when the dynamo is direct on, the condenser current is about 10 ampères, and this exerts only a small influence on the strongly-magnetised magnets. When transformers are used, the field magnets are weak, whilst the condenser current rises 40 ampères.

Mr. BLAKESLEY'S method of determining losses was, he said, inapplicable except where the currents were sine functions of the time, and consequently could not be used to determine loss due to hysteresis in iron, or in a transparent dielectric.

Mr. SWINBURNE'S "Note on Electrolysis" was postponed till next meeting.

NEW PATENTS—1890.

19033. "Improvements applicable to switches used for electrical purposes." WOODHOUSE and RAWSON United, Limited. (Communicated by A. W. T. Hinde, Australia.) Dated November 24.

19034. "Improvements in automatical electrical apparatus." R. J. JONES and WOODHOUSE and RAWSON, United, Limited. Dated November 24.

19035. "Improvements in dynamos for firing explosive charges or for medical purposes." F. W. DODD. Dated November 24.

19037. "Means of neutralising or controlling the polarity of iron or steel for the protection of magnetic needles from local attraction." J. S. GISBORNE. Dated November 24.

19049. "Improvements in electric lighting appliances for photographic and other purposes." F. L. MUIRHEAD. Dated November 24.

19052. "Improved combination of ingredients constituting a compound as an illuminating medium for electric incandescent lamps." M. N. MALLISON. Dated November 24.

19057. "Improvements in electric arc lamps." W. P. THOMPSON. (Communicated by R. H. Beach, United States.) Dated November 24. (*Complete.*)

19076. "Improvements in electric safety fuses." W. M. MORDEY. Dated November 24.

19079. "Electric cables." J. ARMSTRONG. Dated November 25.

19083. "An automatic electrical latitudinal indicator and ships' course registering compass." J. O'NIEL. Dated November 25. (*Complete.*)

19097. "Improvements in and in the method of manufacturing incandescent electric lamps and other exhausted receivers." A. M. CLARK. (Communicated by A. Bernholdt and J. Glatz, United States.) Dated November 25. (*Complete.*)

19108. "Improvements in or connected with combinations of hydraulic, pneumatic, and electric means for obtaining, transmitting, and applying motive power." C. ADAMS-RANDALL. Dated November 25.

19155. "Improvements in electrical storage batteries or accumulators." H. H. LAKE. (Communicated by G. E. Hatch, United States.) Dated November 25. (*Complete.*)

19162. "Improvements in methods of electric welding and metal working." M. W. DEWEY. Dated November 25. (*Complete.*)

19191. "Improvements in and relating to underground electric tramways." M. WHELESS and S. E. WHEATLEY. Dated November 25. (*Complete.*)

19203. "Improvements in the manufacture of thin metal tubes by electrolysis." L. HAUSMANN. Dated November 25.

19234. "A method of and apparatus for controlling gas lighting in cases of failure of electric light installations." H. C. SWINDELL. Dated November 26.

19239. "Improvements in electric switches." H. BARTON. Dated November 26.

19272. "Electric soldering irons." C. E. CARPENTER. (Date applied for under Patents Act, 1883, Sec. 103. May 10th, 1890, being date of application in United States.) Dated November 26. (*Complete.*)

19308. "Improvements in and connected with electrical distribution of power by alternating currents, and their measurement. J. SWINBURNE. Dated November 27.

19315. "Improvements in electric arc lamps. H. NUNNS. Dated November 27.

19344. "Improvements in electrolysis in general, and particularly in electrolysis of metals. E. PLACET and J. BONNET. Dated November 27.

19345. "Improvements in suspension devices for incandescent lamps." A. J. BOULT. (Communicated by H. Rentzsch, Germany.) Dated November 27.

19355. "An improved electrical connection or plug." S. BACON. Dated November 27.

19406. "Improvements in electric current meters." E. HARTMANN and W. BRAUN. Dated November 28. (*Complete.*)

19418. "Improvements in electrical tell-tales for twin-screw steamers." G. HANNAH. Dated November 28.

19423. "Improvements in apparatus for the electrolytic production of gases." E. A. DUCRETET. Dated November 28.

19467. "Improved electric arc lamp." J. P. BAYLY. (Communicated by A. Wagnière, U.S.A.) Dated November 29.

19485. "Automatic railway signalling by electricity." H. E. G. EARLE. Dated November 29.

19496. "Improvements in insulators." J. F. MUNSIE. Dated November 29. (*Complete.*)

19504. "Improvements in systems of electrical distribution." W. S. RICHARDS and G. B. JAMES. Dated November 29.

19505. "Improvements in the method of, and in the machinery for, the manufacture of lead or metallic boxes and plates for electric accumulators, and other kinds of lead or metallic boxes, plates, tubes, rods and strips of irregular section, or plain, ribbed, corrugated and fluted by hydraulic pressure. A. WYLIE. Dated November 29.

19552. "Improvements in telephonic apparatus, the improved magnets of which may be used in other electrical apparatus or machinery." R. H. COURTENAY. Dated December 1.

19555. "A portable room for telephone." F. A. OETZMANN. Dated December 1.

19601. "Connecting and regulating telegraph, telephone, or electric lighting wires." W. GRIFFITHS. Dated December 2.

19650. "Improvements in the distribution of electricity through accumulator batteries." SIEMENS BROTHERS & Co., LIMITED. (Communicated by Siemens and Halske, Germany.) Dated December 2.

19665. "Improvements in and relating to electro-magnetic traction increasing apparatus for railways." M. W. DEWEY. Dated December 2. (*Complete.*)

19724. "Improvements in carriers, supports, or gallieries, for the shades or globes of electric lights or gas lamps." V. SILBERBERG. Dated December 3.

19740. "Improvements in column printing telegraph receivers." F. H. W. HIGGINS. Dated December 3.

19744. "Improvements in and relating to electric belts and similar appliances." C. B. HARNESS. Dated December 3. (*Complete.*)

19762. "Improvements in and connected with electrically indicating pressure gauges." W. C. MORISON. Dated December 4.

19806. "Improvements in circuit controllers or switches for incandescent electric lamps." N. MARSHALL. Dated December 4. (*Complete.*)

19811. "Improvements in apparatus for use in propelling vehicles by electricity." F. WYNNE. Dated December 4.

19813. "Improvements in the production and distribution of alternate electric currents." A. GAY, W. F. TAYLOR and R. HAMMOND. Dated December 4.

19834. "Improvements in controlling levers of railway signal interlocking apparatus for the application of electricity." W. F. BURLEIGH. Dated December 5.

19840. "Transforming paper or other wrapping material into sufficient strength or pertinacity to use as an insulator in all electrical matters and cables." W. EDWARDS and W. SANDBACH. Dated December 5.

19842. "Improvements in roses for ceilings and wall connectors, for electrical purposes." W. H. STURGE and J. GRUBB. Dated December 5.

19883. "Improvements in or relating to self-controlling electrical signals for the prevention of railway accidents." L. CAPOCCI, C. PICONE and A. SPACAGNA. Dated December 5.

19942. "Improvements in galvanic batteries, and in the electro-chemical formation of chlorine and chlorine compounds applicable for such batteries and other purposes." W. P. THOMPSON. (Communicated by F. Marse, Germany.) Dated December 5. (*Complete.*)

ABSTRACTS OF PUBLISHED SPECIFICATIONS 1889.

16237. "Improvements in electrical mains and in their manufacture." S. Z. DE FERRANTI. Dated October 15. 8d. In order to insulate the several lengths of the rods or tubes, the inventor winds around each length a sheet or sheets of paper soaked in an insulating material, say, for example, melted paraffin, and this he does by rotating the rod or tube and causing it to wind the paper around itself. He uses sheets of paper each of a length equal to the length of the rod or tube to be covered and of any convenient width so that when wound on to the rod or tube the several layers of paper may be complete in themselves and uniform insulation be obtained throughout the length of the rod or tube. 12 claims.

17142. "Improvements in electro-magnetic induction apparatus for tranformers, generators, or motors." L. BOLLMANN. Dated October 29. 8d. Relates to certain parts termed magnetic locks, which might be either of two kinds. A lock of the one kind is a movable piece of iron which in one position forms part of a magnet and in another position makes a break of the magnet so that as the magnetic circuit is thus closed or opened, electric currents are induced in coils surrounding the magnet or parts of it. A lock of the other kind is also a piece of iron forming part of a magnet but of smaller diameter than the body of the magnet itself, and surrounded by a coil through which electric currents can be transmitted in either direction. When they pass in the one direction the magnetic circuit is virtually closed; when they pass in the other direction, that circuit is virtually opened. Thus by alternations of current in the coil of the lock, which remains itself stationary, inductions are caused as in the case where a movable lock of the former kind is employed.

18193. "Improvements relating to the manufacture of insulators and other glass articles and to apparatus for use in such manufacture." DAN RYLANDS. Dated November 14. 11d. Has for its object the manufacture or moulding, more rapidly than hitherto and by labour-saving apparatus, of glass articles and especially of such articles as require a large body of glass in proportion to their size, as, for instance, insulators, insulating jockeys, and other articles in glass ware made principally if not altogether by casting, moulding or pressing the glass in suitably-shaped moulds. 4 claims.

18350. "Improvements in dynamo-electric machines." J. H. DAVIES. Dated November 16. 8d. Consists in placing two separate circles of commutator segments on the spindle of the machine arranged and connected as if from an ordinary commutator every alternate segment was removed and displaced longitudinally on the spindle until it was beyond the original commutator, the gaps between the segments in both circles being preferably filled with insulating material such as mica or glass. 2 claims.

18755. "Improvements in the manufacture of plates for use in secondary batteries or electrical accumulators." A. RECKENZAUN. Dated November 22. 6d. The inventor places a plate of lead or other suitable metal in contact wich one pole of a dynamo or other generator of electricity, and causes the plate to travel under a conducting point, or allow the conducting point to pass over the surface of the said plate. 2 claims.

18841. "Improvements in apparatus for laying and picking up submarine cables." G. DRAPER and P. L. ISAAC. Dated November 23. 1s. 1d. In place of bolting to the deck a number of girders with spaces between, the inventors employ a single steel casting which may taper from the bow to aft, and to the front of this casting they bolt a number of plates or steel castings technically known as "whiskers" projecting over the water and separating and supporting the sheaves in a similar manner to the girders. At each side of the apparatus they place a horizontal grating supported by the two outside whiskers. 5 claims.

19011. "Improvements in dynamo-electric machines." J. HOPKINSON. Dated November 26. 8d. It is usual to construct the cores of the armatures of dynamo machines of plates of iron insulated from each other. These plates are in the form of rings and when of large size are expensive. The inventor attains the same effect as is obtained by entire rings both magnetically and mechanically by employing segments of rings arranged in layers the joints between the segments breaking joint between successive layers. The friction between the plates is sufficient to keep them in place just as well as if they were entire rings. When a high tension is required he winds the conductor on the following principle, for example, suppose there be 12 poles he winds a number of sections on the armature then advances one-sixth part of the circumference and winds a like number then advances another sixth part and wind on, and so on, until the whole is wound. 2 claims.

19190. "Improvements in and relating to induction coils and electro-magnets." E. L. LOVELL and A. F. LLOYD. Dated November 29. 6d. Upon a centre formed either of a solid soft iron pin or of a bundle of soft iron wires, the inventors wind one or more layers of insulated wire preferably also of soft iron. Upon this coil of wire is disposed a split tube of soft iron, or preferably a plate of ferrotype iron, bent into a cylindrical form, which, serving as an electro-magnetic condenser, would be secured by a cap attached to each end of the soft iron pin above mentioned or by equivalent means. 2 claims.

19199. "Improved means for the prevention of polarisation in electric batteries." H. BADCOCK, H. GRUNSELL and A. WALKER. Dated November 29. 6d. Polarisation in electric batteries is prevented by imparting a continuous or periodical motion or disturbance to the liquid, the invention being primarily intended to be used with bichromate of potash batteries. 1 claim.

19525. "Improvements in electricity meters." W. H. SCOTT and L. PARIS & SCOTT, LIMITED. Dated December 5. 8d. Consists of modifications and improvements to the apparatus described in Letters Patent dated 1888, No. 16,623. 7 claims.

19554. "Improvements in the connections of alternating current generators and electric motors." M. VON DOLIVO-DOBROWOLSKY and "ALLGEMEINE ELEKTRICITATS - GESELLSCHAFT." Dated December 5. 11d. The different coils, instead of being independent, are conductively connected together in each machine, and the connections between the respective coils of the two machines are such that the coils of the generator supply electric impulsions to two or more of the connecting wires or mains simultaneously, though these impulsions vary in degree relatively to each of them, and that each impulsion transmitted through a main is distributed upon two or more coils of the motor. 2 claims.

19555. "Improvements in electrical induction apparatus or transformers." M. VON DOLIVO-DOBROWOLSKY and the Company "ALLGEMEINE ELEKTRICITATS GESELLSCHAFT." Dated December 5. 8d. Claim:—An induction apparatus consisting in a number of cores of iron forming together three or more closed or nearly-closed magnetic systems, primary and secondary coils placed on said cores, electric circuits connected to the primary coils, and means for creating in the said circuits alternating currents of successive phases, for the purpose of causing a continuously-progressive shifting of the magnetic axis and maintaining nearly constant the total amount of magnetism, substantially as described.

19831. "Quick make and break electric switches." C. M. DORMAN and R. A. SMITH. Dated December 10. 8d. Claim:—In switches of the quick make and break class described and shown in the specification of Belna Egger, A.D. 1887, No. 5092, the method of attaching either directly to the handle moved by the operator or to mechanism suitably geared thereto one or more parts so arranged as to positively transmit the motion of the handle to the contact lever in either making or breaking contact and so render the switch effective if from any reason the force of the spring or springs is insufficient to overcome the friction of the switch, substantially as described and shown in the drawings.

19951. "Improvements in electrical switches." H. BAYLEY. Dated December 11. 8d. Has for its object the construction of electrical switches in such manner that the contact pieces (or contact makers and breakers) may make and break contact with the terminal plates or blocks simultaneously over the entire bearing area between such parts and be also capable of rubbing contact therewith. 5 claims.

20856. "Improvements in elements for voltaic batteries." D. G. FITZGERALD and A. H. HOUGH. Dated December 28. 6d. Relates to the use of the "lithanode" mixtures and consists in coating the leaden support electrolytically with a layer of peroxide of lead before applying any of the mixtures. 4 claims.

1890.

7383. "An improved battery element." J. N. LEVSEN. Dated May 12. 6d. Claim:—A new battery element, consisting of the carbon and zinc electrodes, a mixture of pulverised retort carbon and manganese, covered with a mixture of resin and pitch, all approximately in the proportions set forth, and a sack of sail cloth or other like material encompassing the whole, substantially as and for the purposes described and illustrated in the drawings.

7465. "Improvements in apparatus for telephone exchanges." J. E. KINGSBURY. (A communication from abroad by the Western Electric Company, of Chicago). Dated May 13. 8d. Relates to multiple switchboard systems of telephone exchange, and its objects are, first, to reduce the amount of wiring required between the different boards; and, second, to reduce the size of the switches, so that a larger number of lines may be brought within the reach of each operator. 12 claims.

CORRESPONDENCE.

Improvements in Telephone Switchboards.

I have seen the correspondence going on relative to the above subject, and as I am much interested in this important matter of switching, I should feel obliged if Mr. Kingsbury would answer the following questions, viz.:—

1. Seeing that 14½ feet is occupied by 1,000 subscribers, what is the greatest stretch, in feet, of the cord, presuming that the 10 boards are in one line?

2. In the event of 2,000 subscribers to the exchange at which these boards exist, in what manner would the boards be arranged?

3. What number of operators are employed to work the 10 boards, and would the number be double for 20 boards?

4. When would the exchange attain multiple rank, and in what manner would the boards and connections be arranged for such?

5. Where is the exchange at which these ten 100-line boards exist?

6. Why not give an outline of the connections, as was done in the single-cord system, and thus allow one more able to judge its merits?

Mr. Kingsbury is evidently much in favour of his own system, and dislikes that patented by Messrs. Jackson and Sinclair; but having been shown the single-cord system by the latter gentleman, I must say *I admired the perfectness of its working.* I observe that Mr. Kingsbury has obtained protection for certain details in his system, but I fail to see, by his article of 31st October, anything very special in it, and therefore I may trouble you, ere long, with the illustration of an unpatented arrangement, proposed by myself, with a view of arriving at, or perfecting, a system worthy the brains of England's electricians.

An Electrician all his Life.

December 20th, 1890.

The Institution of Electrical Engineers.

Allow me to make two very necessary corrections in your report of the observations I made at the last meeting of the Institution of Electrical Engineers. The formulæ:

$$(PO_4)_{10}\,(H_2\,O)_5\,Pb\,SO_4 = (H_2\,Pb_2\,O_5)_5\,Pb\,So_4.$$

do not express "the chemical changes produced by electrolysis," but the composition of a certain sample of *lithanode*, which I was inclined to regard as a type of the active material in the negative element of a lead secondary battery. The former of the two expressions is the empirical, and the latter the theoretical formula. The second correction is that I have not yet obtained a discharge of 2 ampères per lb. gross weight of cell for two hours. This is what I am trying to get; but one and a-half ampères for the two hours is the most I have actually obtained.

Desmond G. FitzGerald.

[We are sorry that Mr. FitzGerald should be compelled to write to us; the report is not ours, but the authorised abstract of the discussion sent out under the auspices of the Institution. There was a time when such corrections would not have been necessary.—EDS. ELEC. REV.]

Underground Cables.

In your issue of the 19th inst. you publish two letters, one from Mr. Mavor and the other from Mr. Ferranti, having reference to a letter from our Liverpool agent published in the ELECTRICAL REVIEW of the 5th inst.

With regard to the cables in use at West Brompton, the statement made in the paper on Central Station Lighting was that the Fowler-Waring cables were not exclusively used by the House-to-House Company, but have been found to be the most satisfactory up to the present time. From Mr. Mavor's letter it would appear that we are incorrect in saying that these cables have been abandoned at West Brompton, and that their use has only been postponed. If this is so, still they can hardly be considered as "the most satisfactory up to the present," as our vulcanised cables are, we understand, in daily use; and Mr. Mavor admits that the difficulty to be overcome before the Fowler-Waring cables can be used is a serious one. This difficulty presumably existed at the time the paper referred to was read in January, and it appears has not yet been overcome, and the cables have not yet been in ordinary service.

With regard to the London-Deptford cables, the original statement made was, that "certainly these have been the only cables which have withstood the voltage employed by the London Electric Supply Corporation for any time; and though they subsequently developed faults, the tension (*i.e.*, 10,000 volts) was phenomenal," &c.

From Mr. Ferranti's letter it would appear that these cables are only working at 2,500 volts, and are not sufficiently insulated for the higher voltage. This does not bear out the original statement made—that these are the only cables which have withstood 10,000 volts; and although the expression, "we believe these cables have been condemned," may appear strong, in your issue of the 4th April last you refer to the "breaking down of the Fowler-Waring cables," and in the report of the meeting of the London Electric Supply Corporation contained, in the same issue, the following occurs as an extract from the engineer's report:—"The defective mains now in use between Deptford and London will shortly be replaced by these permanent trunk mains" (*i.e.*, mains manufactured by Mr. Ferranti); and, further, in your issue of the 25th of the same month, you state "That the cables, so far, have proved to be unreliable is well known."

Surely if such statements go uncontradicted, it is a fair assumption that these cables are not reliable, and that they are to be replaced—in other words, that they are condemned.

We wish to point out that, no doubt from an oversight, several words of our agent's quotation from Mr. Ferranti were omitted from his letter, as printed in your issue of the 5th inst., and that by this omission the sense of the paragraph is entirely altered.

Wm. J. Tyler,
Secretary of the I.-R G.-P., and T.W. Co., Lim.

22nd December, 1890.

British Insulated Wire Company's Cable.

Owing to absence from Liverpool, I have just had the pleasure of reading your issue of the 12th to-day, and I notice therein a leaderette criticising the data of some tests of the above-mentioned company's manufactures.

You apply certain terms to my letter containing the figures observed, which, representing as they do your opinion, cannot be cavilled at, but how far they are merited by the MSS. you so roughly handle is questionable. The truth only having been recorded in the report referred to, it is open to anyone to cavil at the mere style of the writer, which may afford sport to any Philistine.

You state that you find "it difficult to judge of the value of the tests from insufficiency of information."

The tests were taken solely to ascertain the dielectric resistance under various conditions, electrification and capacity of electric light and telephone cables, sample lengths suitable for the purpose being used. As the tests were completed satisfactorily, mechanical data of the cables were not included. As I am aware that all your comments are intended for the public good, there is no better reply to make to your statements than to ask you to again look into the figures and impartially to weigh the results obtained which have here and elsewhere been considered most favourable. It is questionable if the substance of the letter could have been given in a few lines, as the matter included only contained such information as would be required by anyone attempting to repeat these tests. The cables were all lead-covered, but the reference made to the telephone cable maintaining its insulation in the rain had regard to the fact that the lead had been stripped off for about 12 inches at each end, and it was in this condition that the sample was left exposed, and tested after merely surface drying.

The two-yard length of electric light cable had been twisted and bent after the lead sheathing had been removed, and before immersion. In comparison with certain other cables of similar type of insulation, the test was very severe, and is conclusive evidence that the material used does not absorb moisture.

It is, of course, of the greatest interest to the electrical world to ascertain the accuracy and magnitude of tests made on cable samples, and in this light your leaderette has, I trust, elicited the information desired.

Charles H. Yeaman.

2, Albany Place, Glasgow, W.
December 20th, 1890.

[Mr. Yeaman has now given the information, of the lack of which we complained. The results of the tests (which we consider were properly made) under the conditions stated, certainly show the insulation of the cables in a very favourable light.—EDS. ELEC. REV.]

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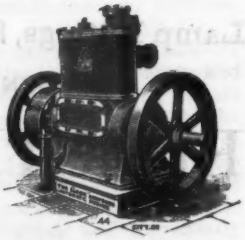

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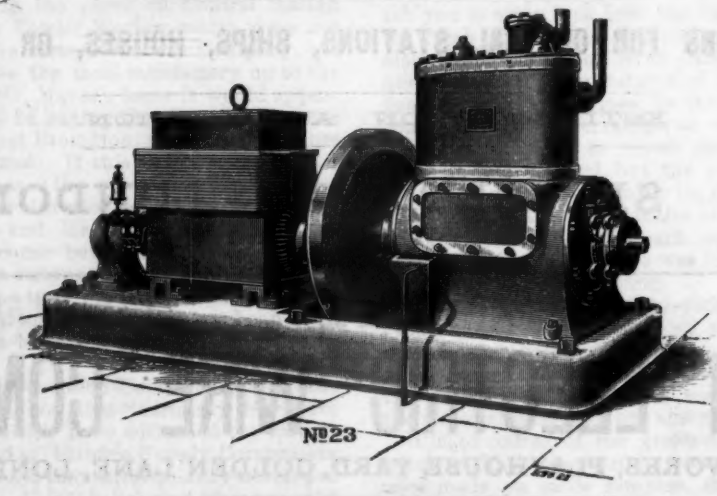

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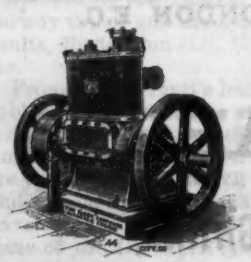

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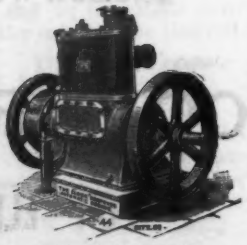

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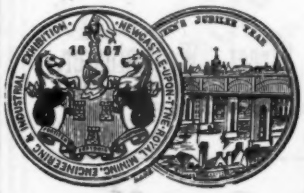

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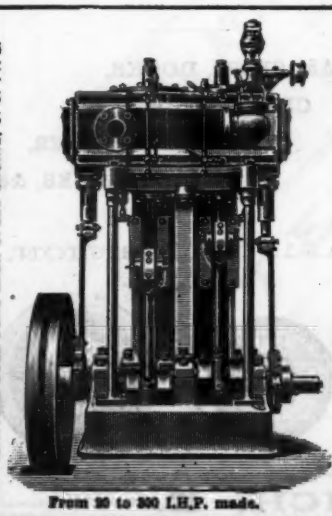

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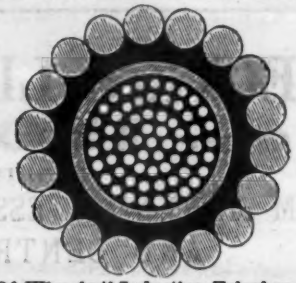

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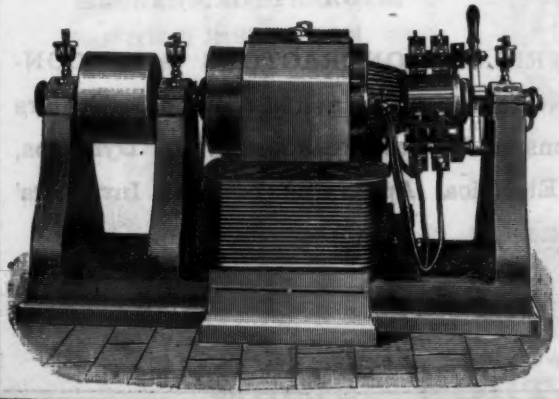

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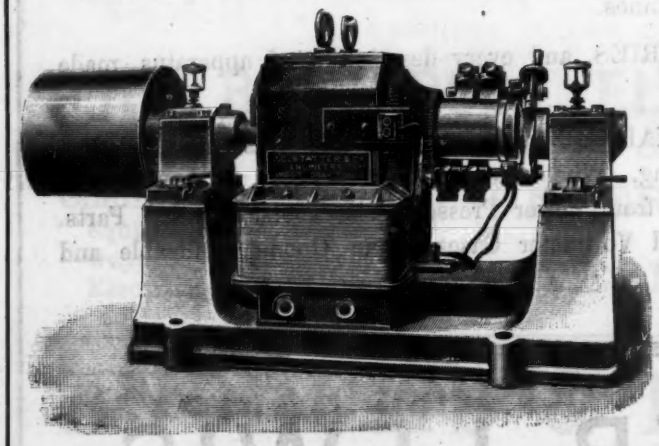

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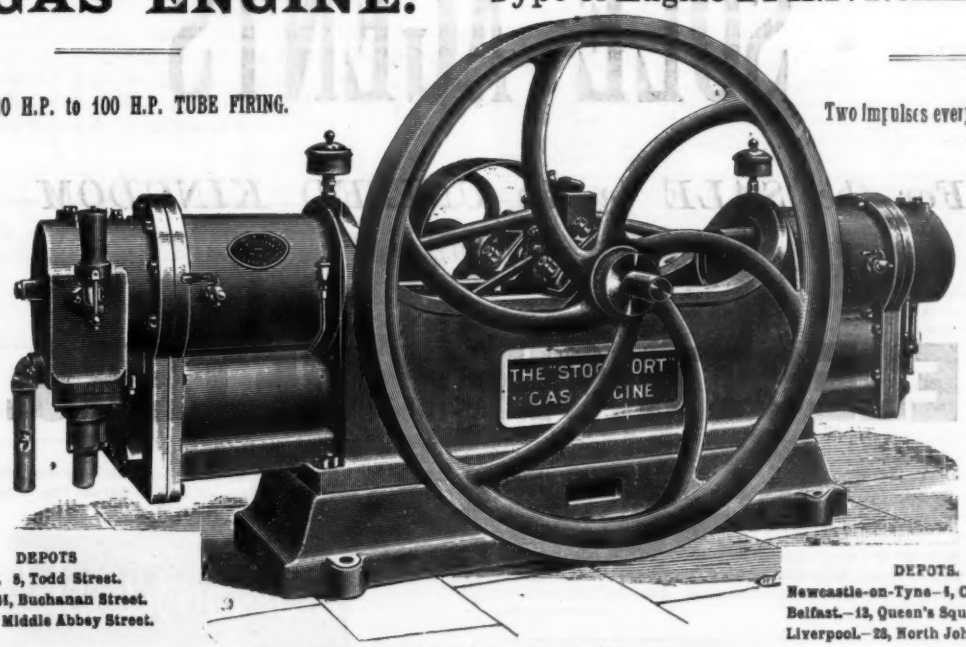

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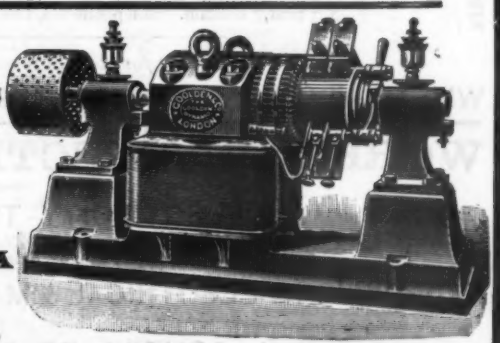

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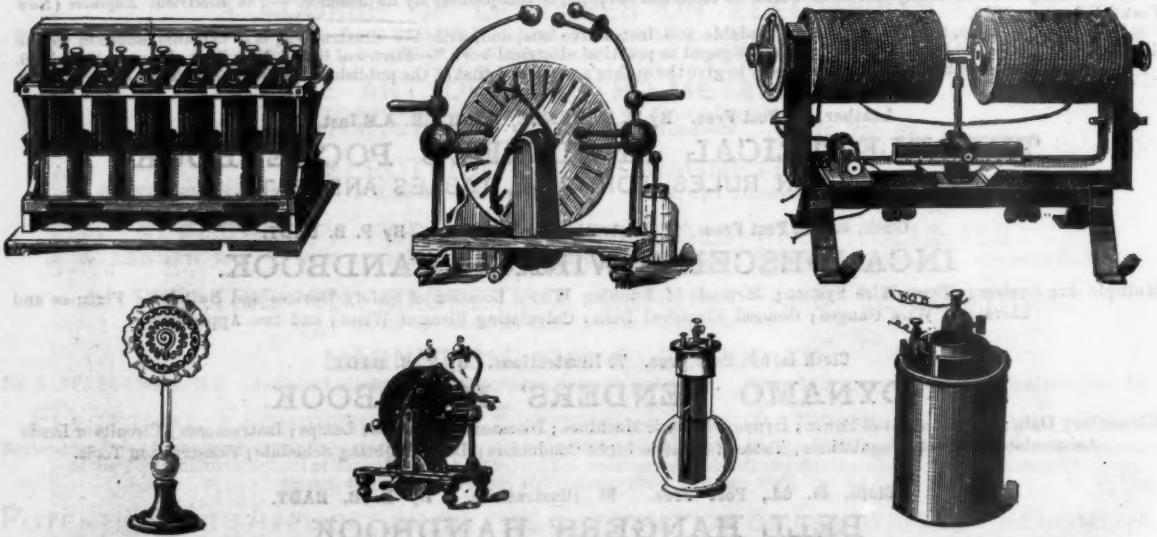

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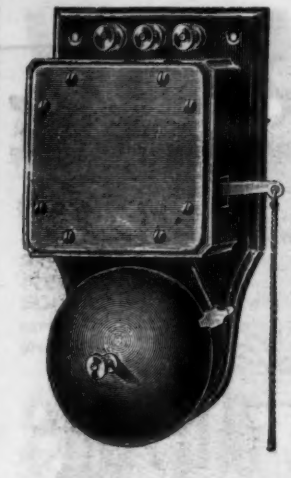

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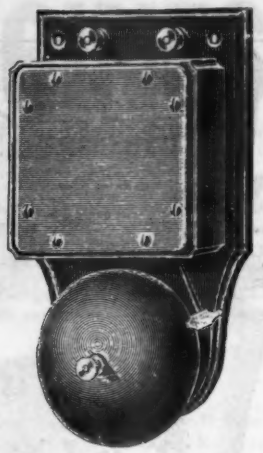

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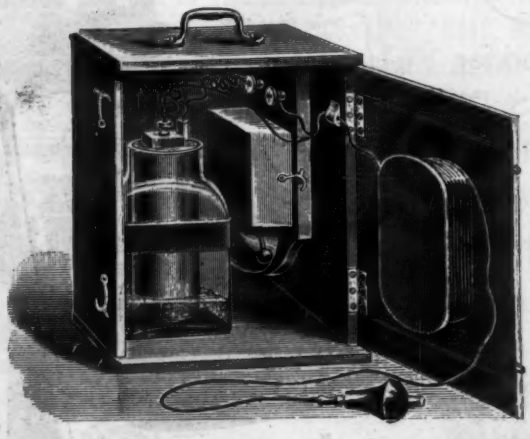

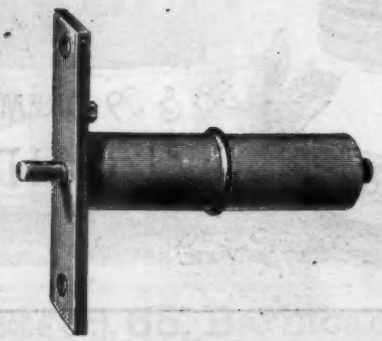

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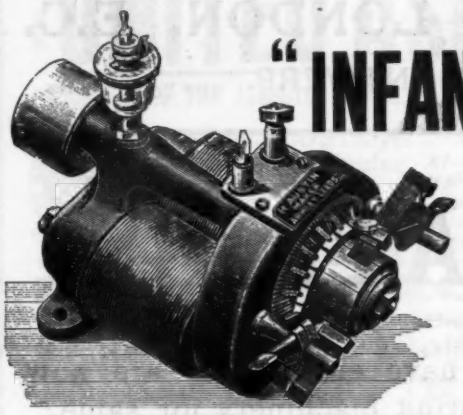

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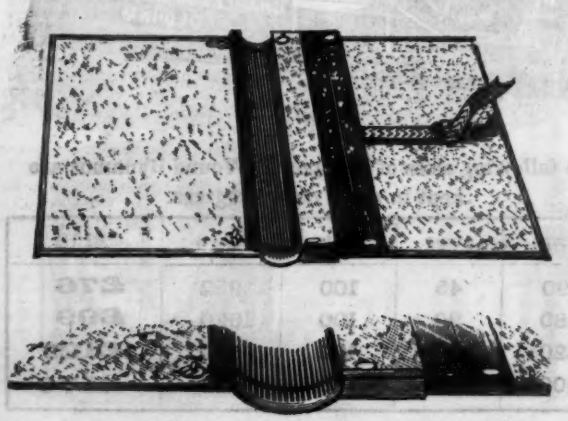

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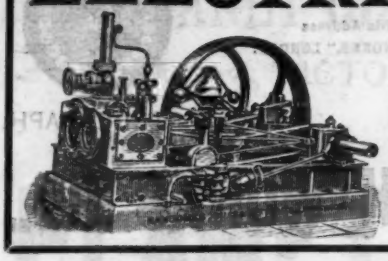

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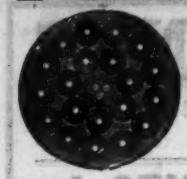

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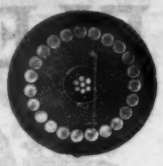

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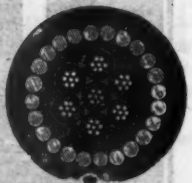

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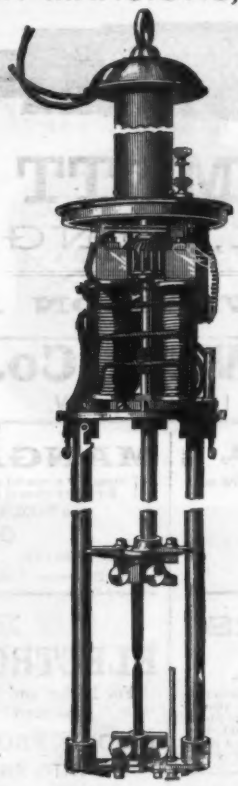

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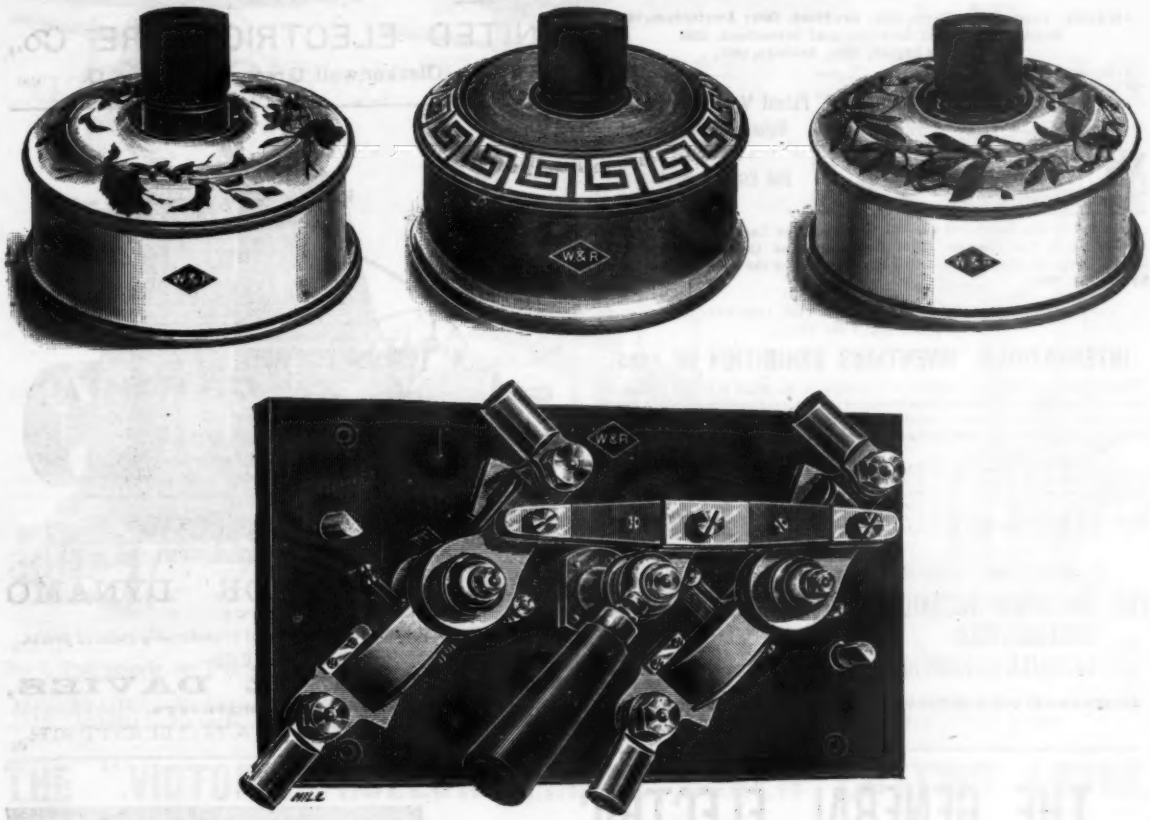

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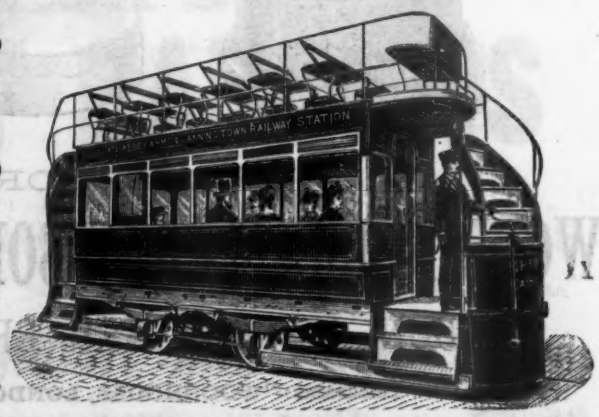

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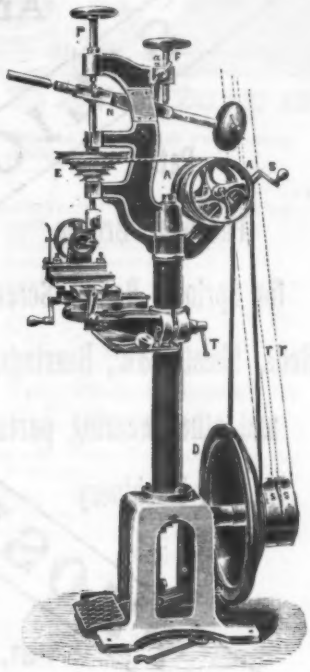

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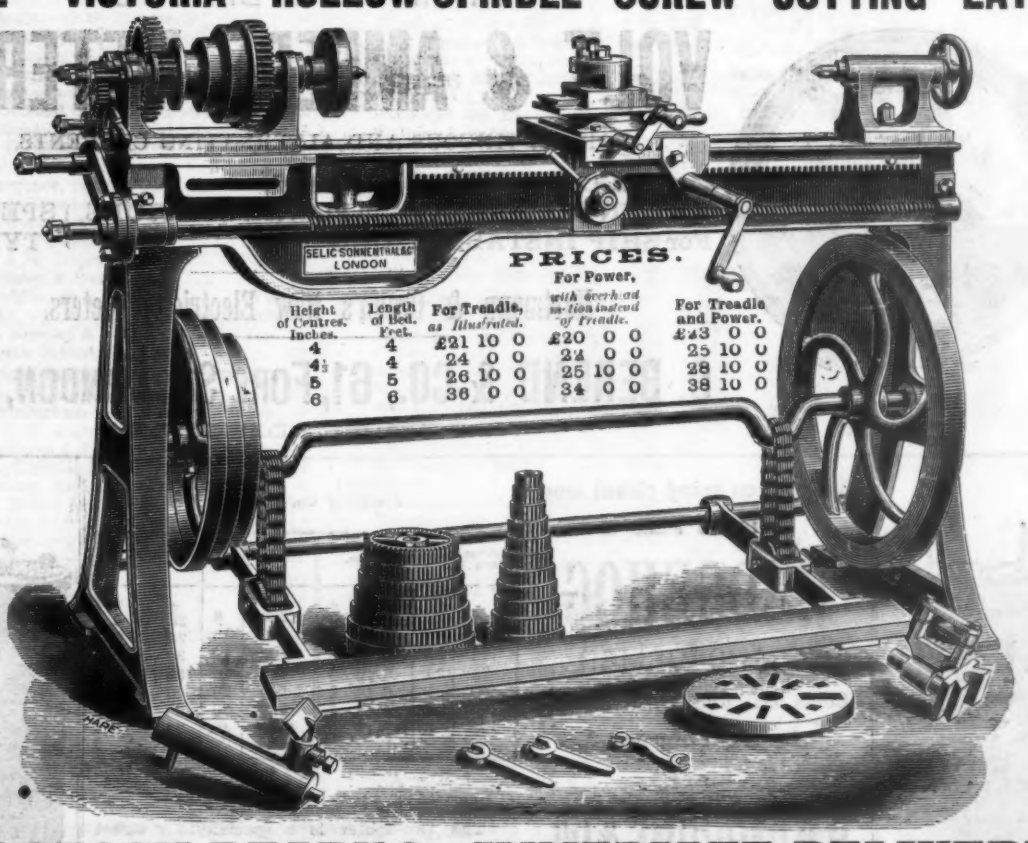

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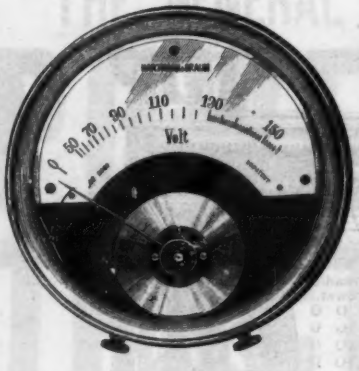

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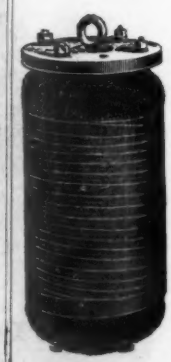

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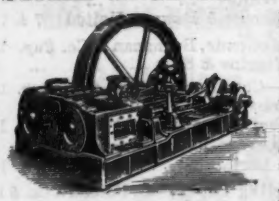

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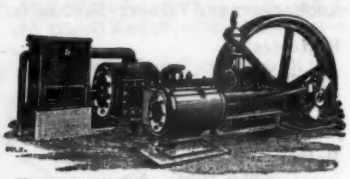

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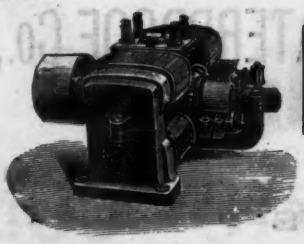

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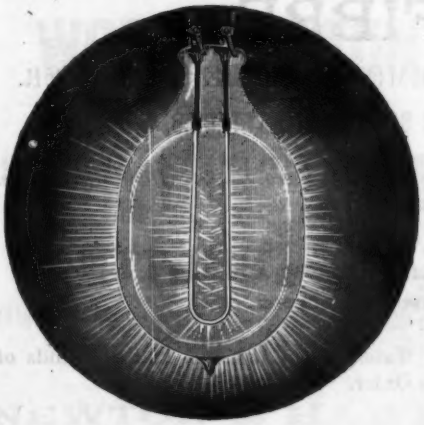

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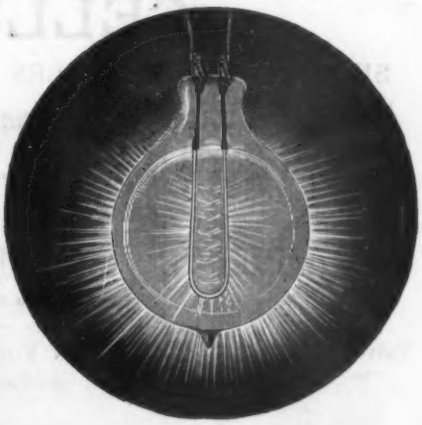

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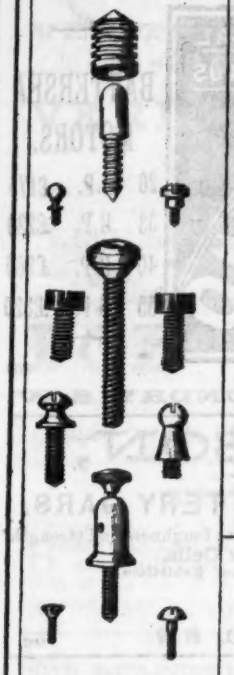

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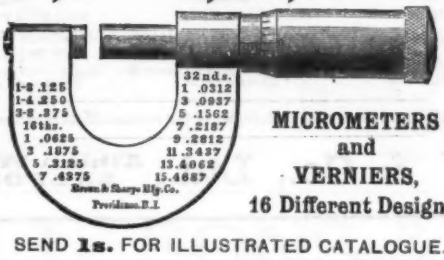

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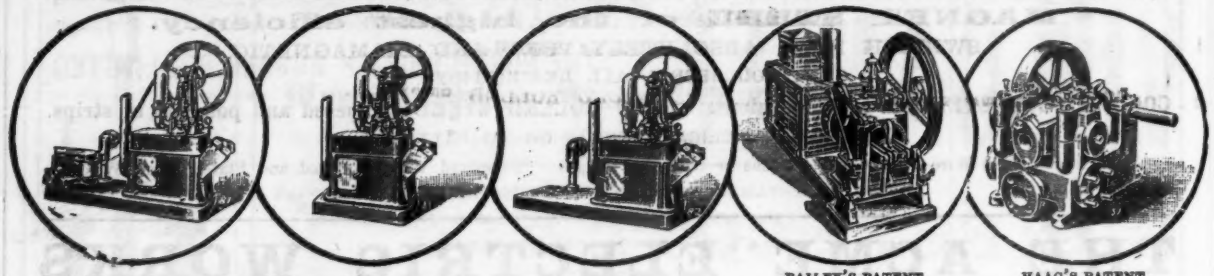

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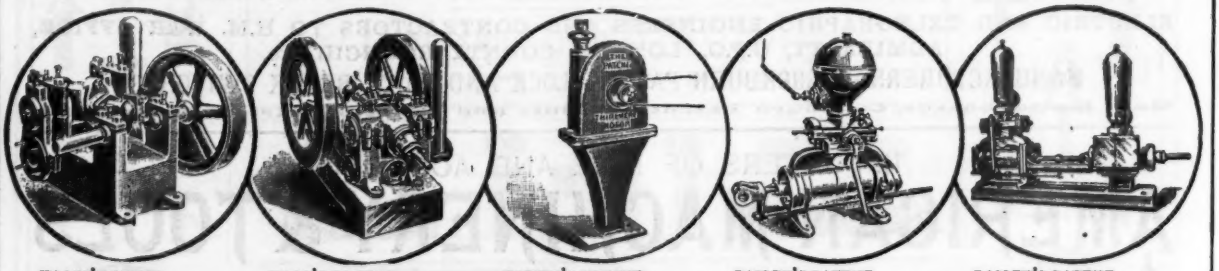

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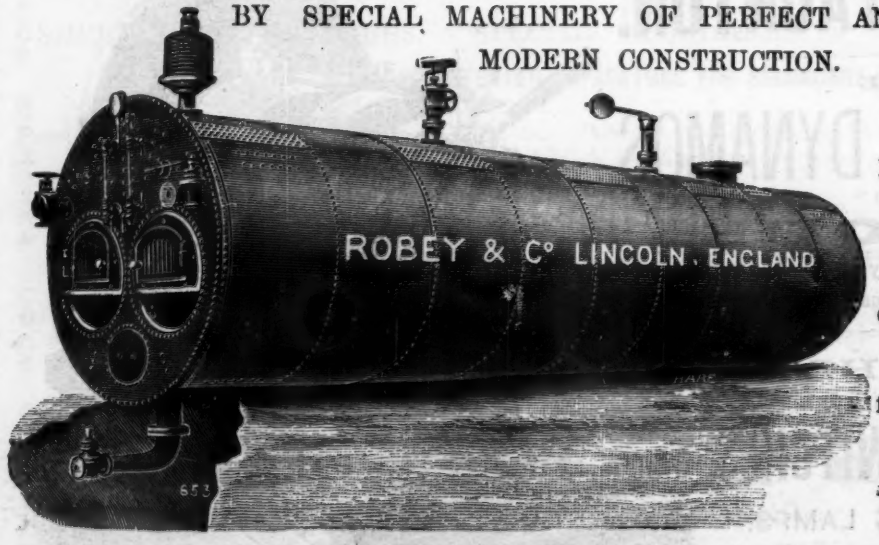

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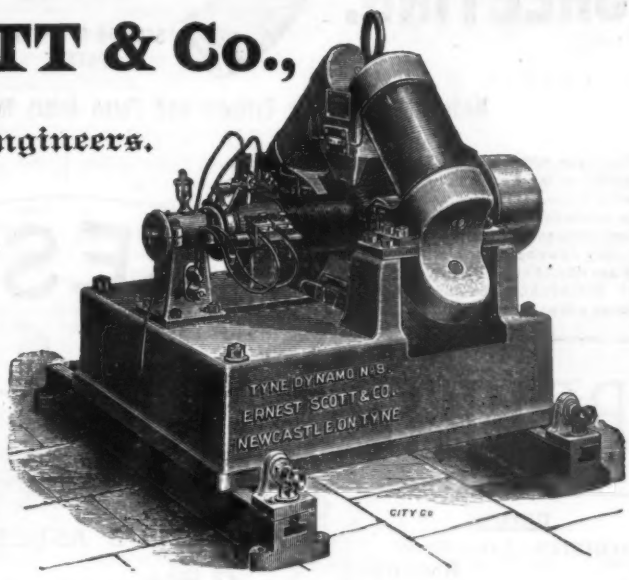

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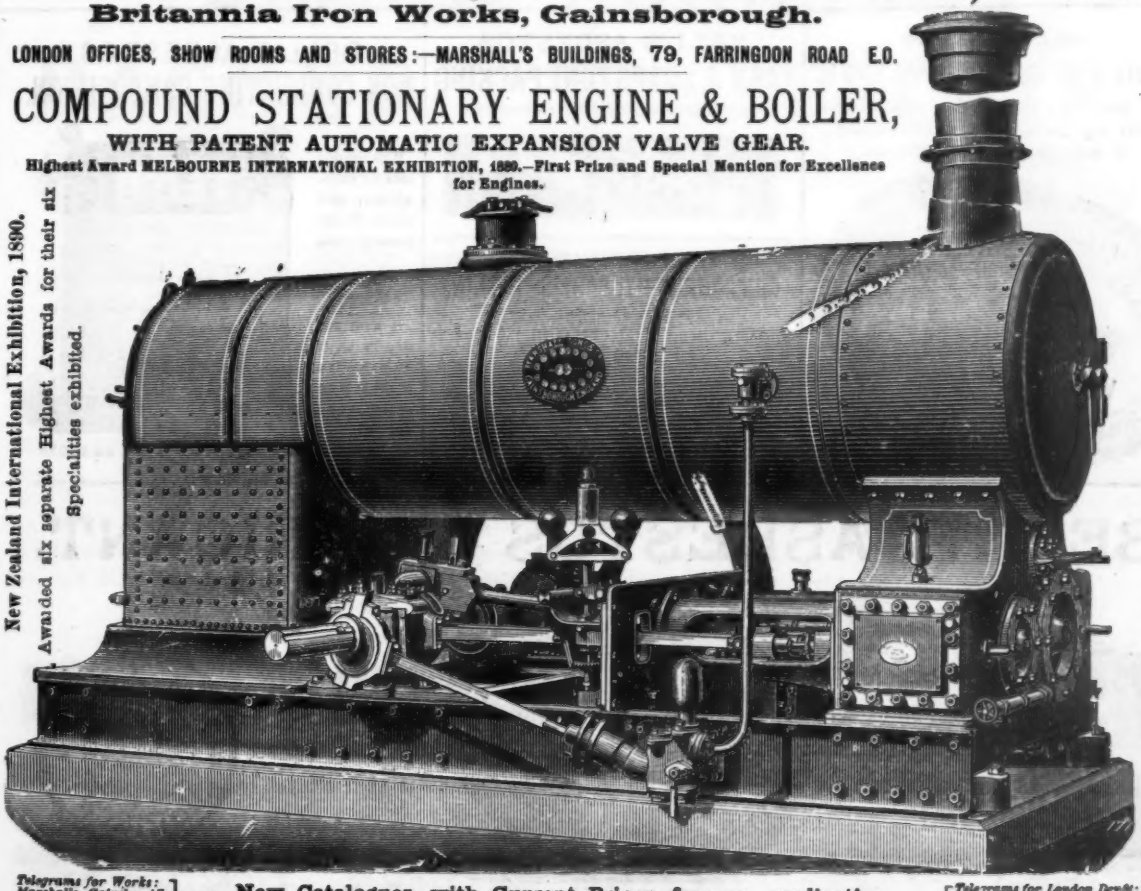

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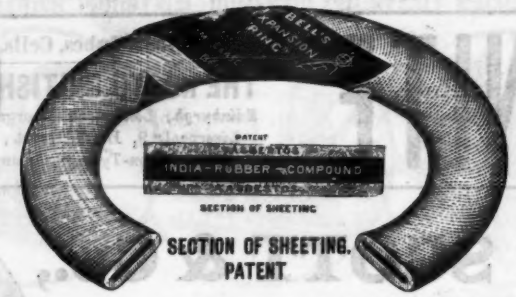

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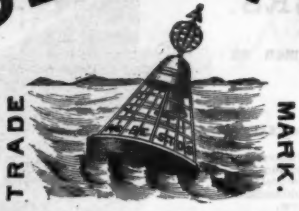

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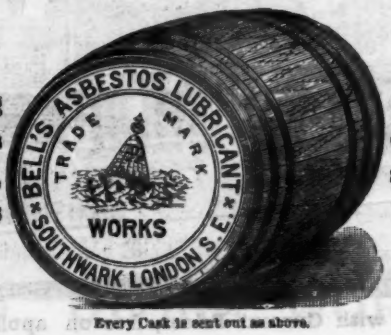

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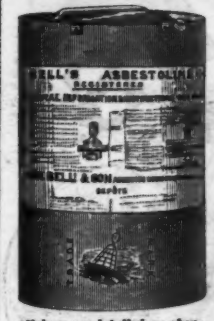

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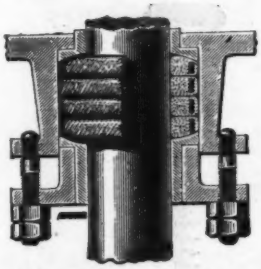

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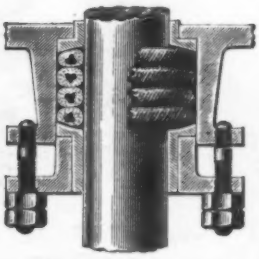

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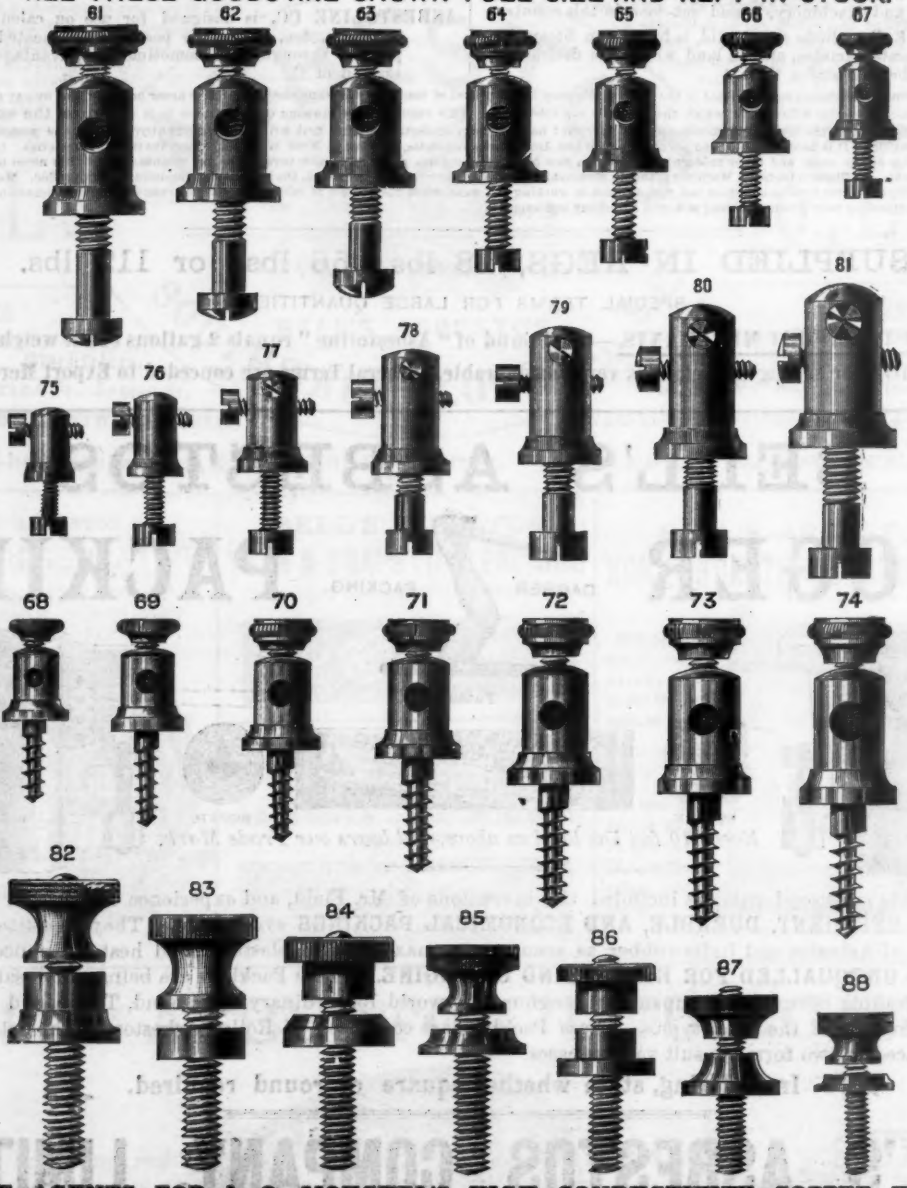

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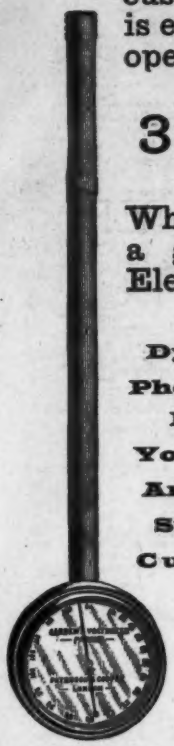

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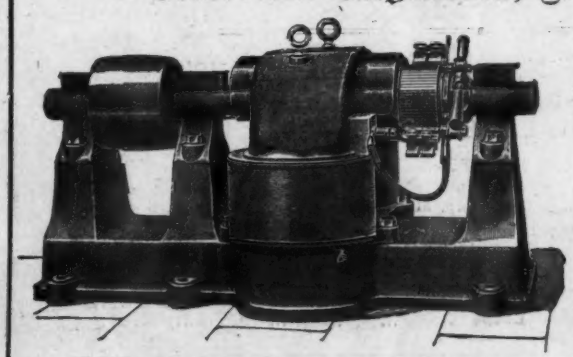

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